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THE GLASGOW MEETING, 1958

THIS year's Meeting of the British Association was its sixth in Glasgow—a distinction which Glasgow shares with Birmingham, Edinburgh and Oxford. The first Meeting in Glasgow, it is recorded, was so successful that the Association did not wait long before returning—as it did in 1855. That Meeting was welcomed by a delicate tribute in the editorial columns of the *Glasgow Herald* on September 14, 1855, in which the arrival of 'the philosophers' is announced and the writer explains, 'Our readers will easily understand the reason why our columns are so full of matter which is foreign to the usual contents of our journal'. Having saluted the main event of the day, the writer proceeded to the next item, 'The Fall of Sebastopol'!

Since those days a different world has come into being—a world in which the functions of the Association are necessarily, and properly, altering in response to changing needs and circumstance. A leader writer in *The Scotsman*, commenting on the opening of this year's Meeting, defines very clearly one of the Association's major functions today:

> At the meetings of the British Association for the Advancement of Science, the interested layman may obtain a picture not only of scientists, but of the scientific activity itself, not only of what science has recently done, but of what it is doing in a thousand and one specialised fields. . . . Never at any time was it more necessary for the layman to have proper understanding of scientific work, for in a scientific age political decisions increasingly depend on points of scientific information. . . . The temptation for the scientist is to be content with his expertise, and regard the wider public as ineducable; for the layman to refuse the mental effort of being educated. The British Association provides an admirable meeting-place.

It is generally agreed that the Meeting in Glasgow, the scene for which was so competently set by the Local Committee, on behalf of the Association's hosts, the City and the University of Glasgow, was most successful. With becoming modesty the author of an article on Glasgow, prepared for members attending the Meeting, says that the 'University, with six thousand students, is not without repute'. We are told also that the Papal Bull of January 7, 1451, justified the choice of Glasgow as the site of Scotland's second university as being 'a place where the air is mild, victuals are plentiful and a great store of other things pertaining to the use of man is found'. It would not be entirely fanciful to apply this description to the University of today, for rarely can the Association have been provided with such splendid help and facilities for its meetings—the weather, moreover, remained equable and members found their 'victuals' conveniently at hand in the University refectories. The buildings of the University provided, indeed, an admirable centre for the simultaneous sessions of the thirteen Sections and made easy those movements from one Section to another which are an important feature and a justification of the Association's meetings. The Assembly of Corresponding Societies met nearby in the Kelvingrove Museum and Art Gallery and a number of important sessions of certain of the Sections were held in the rooms of the Royal College of Science and Technology.

The scientific sessions of the Sections began on the morning of Thursday, August 28—the Presidential Addresses and major sessions being timed, where possible, to avoid clashes of interest so as to allow members to enjoy as varied an intellectual menu as possible.

The titles of the many individual contributions to the programme are listed, together with informative abstracts, on pages 269–303 below. It must suffice here to

say, in summary, that the scientific programme was outstanding: there were up-to-date reviews of the progress of fundamental research in fields as varied as those dealing with the thermonuclear research, life at low temperatures, the nature of viruses, colour vision, and nitrogen metabolism; there were many papers and symposia of special Scottish interest, including those on science and hill-farming, Scottish soils, and water resources and water needs; there were many papers of topical interest and importance, of which those concerned with the major problem of the education of the scientist should perhaps be specially noted—the Presidential Address by Sir Willis Jackson on 'The partnership between industry and education' and sessions on 'The teaching of mathematics', 'Education in a technological age' and 'Physiology as a career'; there were also a number of illuminating joint sessions between Sections which dealt with subjects such as geology and oil, heat-transfer, host–parasite relationships, the integration of agriculture and forestry, and progress in microscopy.

Members began to arrive for the Meeting early in the week, and the Reception Room opened in the Hunter Hall West of the University on the morning of Tuesday, August 26. It soon assumed its customary appearance of purposeful activity, which it maintained throughout the week. Members transacted there all their business in connection with the Meeting. They received, amongst other things, free travelling passes on the City's transport services—a most welcome and generous gift from the Local Committee. There also, latecomers were able with the help of officers of the Scottish Tourist Board, who had, in previous months, made the arrangements for the accommodation of visiting members, to find places to stay in an already very crowded city. In the adjacent Hunter Hall East, the Press Bureau was established under the supervision of Mr. W. A. Nicholson, O.B.E., Manager and Secretary of the Scottish Tourist Board—an accomplishment which was all the more noteworthy in that he was at the same time engaged in running a major press service for the Edinburgh Festival. The Association were very much in the debt also of the Nobel Division of I.C.I. Ltd. for the provision of a hard-working and efficient team of girls under the supervision of Miss Hunter—a team which alone made possible the preparation of the immense amount of press material issued to the many representatives of the local and national press and of the scientific and technical journals present at the Meeting. The magnitude and success of the effort may be gauged from the very full and excellent press, radio and television coverage of the Meeting which was achieved despite the competing and compelling interest of the second 'Atoms for Peace' conference at Geneva and of all the other current news of political and international significance.

The business of the week began on the morning of Wednesday, August 27, when the President and other senior officers were entertained by the Lord Provost of Glasgow and the Chancellor and Principal of the University at an informal reception in the College Club of the University.

During the afternoon of the same day, the General Committee, the governing body of the Association, met in the Logic Classroom of the University and elected Sir James Gray, M.C., C.B.E., F.R.S., as President of the Association for 1959.

Sir James has been Professor of Zoology at Cambridge for twenty-one years, and has played a leading part in re-establishing the functional analysis of living cells and living animals as a major object for zoological research. He is chairman of the Advisory Committee on Fishery Research, and has taken a particularly active and personal interest in the study of salmon.

The General Committee received a report (which appears in full on pages 257–260 below) on the progress of plans for the new activities announced at Dublin in 1957. They received with pleasure further reports that a special grant of £5,000 per year for two years had been received from an industrial donor to enable the Association to launch a special scientific programme for young people and that a

Study Group, which would be financed by a generous grant from the Leverhulme Trust, had been set up to examine the education of the graduate scientist in school and university, under the chairmanship of Dr. R. P. Linstead, C.B.E., F.R.S.

At the conclusion of the meeting, Sir Alexander Fleck attended a ceremony in the Department of Physical Chemistry of the University at which he unveiled a bronze plaque in memory of Frederick Soddy, F.R.S. Soddy came to Glasgow in 1904, already widely known for his researches in radio-activity with Rutherford and Ramsay. He was awarded the Nobel Prize in chemistry for his researches into the origin and nature of isotopes. Sir Alexander Fleck recalled that Soddy had been present at the Meeting of the British Association in Glasgow in 1901—as an unknown junior scientist.

The Inaugural Meeting was held in St. Andrews Hall on the evening of Wednesday, August 27, before a large audience representative of many branches of science and of the City's life and activities. The Lord Provost of Glasgow, Mr. Myer Galpern, welcomed the Association on behalf of the City, and he was followed by Lord Boyd Orr and by Sir Hector Hethington, who spoke on behalf of the University. The latter concluded his welcoming speech by saying that the University had done its best to make all the arrangements necessary for a successful Meeting, even to the creation of a new topographical term, 'Coffee-point', where apparently, he said, 'one gets one's *tea*'. The Lord Provost then invited the President to take the chair. Sir Alexander Fleck, describing himself as 'a lapsed scientist among business men', then delivered his address on 'Science and business—a balanced partnership', the full text of which appeared in the September issue of the Advancement of Science (pages 3–12). At the conclusion of the Presidential Address, a vote of thanks to Sir Alexander Fleck was proposed by Professor P. M. S. Blackett, F.R.S., in the following terms:

My Lord Provost, My Lords, Ladies and Gentlemen. There are many special reasons why I am pleased to have been called upon to thank our President, Sir Alexander Fleck, for his masterly address. I found it to be original, wise and eminently practical. I am one of those who believe that, from time to time, it is fitting for a President of the British Association to take, as the theme for his address, a subject of wide scope and of great national importance. Sir Alexander has certainly done this. To be elected President of the British Association is rather like being appointed a temporary lay archbishop. And archbishops preach sermons: so why shouldn't the President of the British Association? I am sure you all agree that Sir Alexander has given us an excellent and most valuable lay sermon.

It is, I feel, a very happy set of circumstances which led to Glasgow being the city for the Meeting under Sir Alexander's presidency. Born on the south bank of the Clyde, by great intelligence, pluck and hard work, he graduated from lab. boy in Glasgow University to a teaching post in the (University) Department of Physical Chemistry. As a colleague of Professor Soddy, co-worker with Rutherford, and Nobel Laureate, he investigated the chemical properties of many radio-elements and so earned a worthy place in the history of atomic physics—and incidentally, a mention in Eve's life of Rutherford.

Before I leave the subject of Glasgow, I do want to tell you how honoured I feel to have been recently made an Honorary Doctor of this old and great university. My own contact with Glasgow goes back forty-three years. For in 1915, as a midshipman in the Royal Navy, I joined the famous battleship H.M.S. *Barham* on completion at John Brown's yard on the Clyde.

In his address our President said some very important things, based, on the one hand on his training as a research worker in pure science, and, on the other, on his forty years as an applied chemist, as administrator of science, and as a business man. The climax to his remarkable career came with his election in 1953 to the chairmanship of that great industrial complex, the I.C.I. Two years later the Royal Society of London honoured itself by electing him a Fellow.

All here will agree with him that if Britain is to remain a great power and to enjoy an increase of material wealth, then we must all strive for an intimate partnership between

the scientist and the business man: and that profitable business enterprises are as important as creative engineers and scientists.

In the past Britain has undoubtedly suffered from this lack of partnership. Some scientists have, I fear, acted in the past as if they thought business rather non-U. And business men have often, and sometimes rightly, felt that scientists were impractical and a bit of a nuisance. The last years have seen a marked change—stimulated in part by the experience of the Second World War, during which, it is rumoured, that slide-rules have been flourished at Cabinet meetings! I am sure today that slide-rules can often be seen peeping out of the pockets of directors at I.C.I. board meetings.

A most impressive aspect of our President's address was its broad sweep, ranging from the great slump of the 1930's to the sputniks of 1957. The relation between research, development and exploitation, the education of the scientist, the lessons to be learnt from foreign countries, the place of scientists in business administration—all and more were discussed with penetration and wisdom: one saw clearly displayed the qualities which have made Sir Alexander Fleck one of the greatest business men of our day.

Mr. President, on behalf of the British Association, on behalf of your native city of Glasgow, on behalf of Great Britain, I thank you.

Following the Inaugural Meeting, there was an informal coffee party for visiting research students at Hetherington House—the University's Research Students' Club.

On the morning of Friday, August 29, Sir Alexander Fleck presented prizes to the winners of the 'Endeavour' essay competition at a reception in the Randolph Hall of the University at which exhibitioners and selected students from universities and colleges all over the country were also present. The first prize was awarded to Mr. Charles Perrin of Winchester College for an essay on 'Darwinism To-day', the text of which will appear in a future issue of this Journal.

The same afternoon the President was honoured by the Royal Faculty of Physicians and Surgeons of Glasgow at a ceremony at which he was elected an Honorary Fellow of the Faculty. In thanking the Faculty for the great honour that had been conferred on him and other Honorary Fellows, Sir Alexander Fleck pointed out that fellowships had been conferred on fifty-six persons in the 359 years that the Faculty had been in existence. That was one Fellow in every six and a half years—so that the elections on that day would last the Faculty for a very long time!

In addition to the scientific programme, there were a number of general and sectional exhibitions (in Sections B, C, D, E, H, I and J) on view during the week which drew large and interested audiences. The general exhibitions included a display of books for the non-specialist reader arranged by the National Book League, an exhibition of the work and activities of the Scientific Societies of Glasgow and district, and a centenary exhibition of the work of the Geological Society of Glasgow. Of the many sectional exhibitions, space permits notice only of the two which were staged in the Mining Department of the Royal College of Science and Technology. One, entitled 'Geology and Industry', included exhibits showing the impact of geology on several Scottish industries. These traced the history of Scottish shale through its recovery underground, through the various distillation processes, several aspects of local quarrying, and the mining of refractories and lead. The second exhibition was sponsored by a number of the major oil companies to illustrate oil prospecting and drilling methods. The interpretation of aerial photographs for geological surveys is explained, and some geophysical surveying instruments were on show.

Scientific films have now become an accepted feature of Annual Meetings of the Association, and the programme presented at Glasgow was, perhaps, the most important contribution to date. Five programmes, including thirty-three films produced in nine countries, were presented. They included the British première of an American film on 'Life of the Moulds' and the public premières of four new

British films: 'Conquest of the Atom', 'Groundwork for Progress', 'Makers of Science, No. 1: Sir Harold Spencer Jones', and 'Nine Centuries of Coal'. Each of the five main programmes included a film of special Scottish interest, one of which dealt with the story of Sir James Simpson's discovery of the anaesthetic properties of chloroform. The general programme, screened on the morning of Wednesday, September 3, attracted a great deal of interest. It was devoted to the scientific and technical progress of mankind and included a film entitled 'Ellerhammer' (an account of the work of this Danish aviation pioneer), 'Rivers of Time' (which gave an account of the Sumerian and Arabian contribution to the development of civilisation) and 'The Mystery of Matter' (a remarkable Soviet film on the history of scientific investigation).

Two evening discourses were delivered during the week, on both occasions in St. Andrews Hall. On the evening of Friday, August 29, Sir Christopher Hinton, K.B.E., F.R.S., Chairman of the Central Electricity Generating Board, delivered before an audience of some seven or eight hundred people a beautifully illustrated lecture on 'Nuclear power and the engineer', in which he said that the problems and changes in the next ten years in the development of nuclear power plants would be as great as those during the first ten years. (The text of this discourse appears on pages 173–187.) On the evening of Monday, September 1, Dr. C. F. A. Pantin, F.R.S., Reader in Invertebrate Zoology in the University of Cambridge, delivered a discourse on 'Living machinery and the electron microscope' which was distinguished by a remarkable clarity of exposition and by a number of fascinating films showing movement and change within the living cell.

The Glasgow Meeting was memorable also in that a major scientific programme for young people from schools in Glasgow and the West of Scotland was staged in the University. The Association and the young people for whom the programme was arranged are very much in the debt of the distinguished group of scientists, including Sir Lawrence Bragg, F.R.S., Director of the Royal Institution, who so generously devoted their time and experience to making these lectures the huge success that they proved to be. In addition to the lectures a number of special exhibitions were on view—a Schools Science Exhibition arranged by the Scottish Branch of the Science Masters' Association; an exhibition of 'Man-made fibres' presented by the Fibres Division of I.C.I. Ltd.; a display prepared by Unilever Ltd.; and an exhibition provided by the Central Electricity Generating Board which incorporated models of the atomic power stations at Calder Hall and at Berkeley in Gloucestershire and a number of informative display panels illustrating the historical development of atomic energy. Finally, on the Saturday morning there was a most successful open forum under the chairmanship of Dame Kathleen Lonsdale, F.R.S.; the panel (Dr. B. J. Mason, Dr. I. J. Faulkner, Mr. B. B. Lloyd and Dr. W. E. Swinton) dealt with a number of interesting and topical questions, including the following: 'What would be the benefit of a landing on the moon?', 'Is there a risk that human kind might become extinct?', and 'What is the nature of matter?'

Members were entertained during the week on a number of less formal occasions. On the Thursday afternoon the British Council entertained a number of overseas guests, officers of the Association and representatives of the City and University at a reception. The same evening the Lord Provost of Glasgow received members individually at a reception in the Art Gallery and Museum, Kelvingrove. On Saturday evening members were the guests of the Local Committee at an orchestral concert in St. Andrews Hall, where they listened to a varied and attractive programme of music presented by the B.B.C.'s Scottish Orchestra, conducted by Dr. Ian Whyte. The programme included Rossini's 'Semiramide' Overture, Schumann's First Symphony, Brahms's Variations on the St. Anthony Chorale, A Scots Suite by Ian Whyte, and Strauss's symphonic poem, 'Don Juan'.

On Tuesday, September 2, the President and other officers and members of the Association were entertained to lunch by the President and members of the Glasgow Chamber of Commerce in the Central Hotel. The same evening the Council of the British Association entertained at dinner in the Central Hotel, local officers and overseas guests. The Lord Provost, Andrew Hood, replied to the toast of 'The City' and Lord Boyd Orr to the toast of 'The University'. Dr. Alan Waterman, in replying to the toast of the overseas guests, quoted from an address given by Alfred Worth Whitehead in 1916:

In the conditions of modern life the rule is absolute: the race which does not value trained intelligence is doomed. Not all your heroism, not all your social charm, not all your wit, not all your victories on land or at sea, can move back the finger of fate. Today we maintain ourselves. Tomorrow science will have moved forward yet one more step, and there will be no appeal from the judgment which will then be pronounced on the uneducated.

Some three hundred members were invited on the Tuesday evening also to a reception given by the local Scientific Societies in the Art Gallery and Museum.

During the week there were a number of informal Sectional occasions: dinners were arranged by twelve Sections, and Section G (Engineering) were the guests of the Governors of the Royal College of Science and Technology at a conversazione on the evening of Monday, September 1. Members of Section B (Chemistry) and others were invited to a reception given by the Nobel Division of I.C.I. Ltd. on the evening of Tuesday, September 2.

In addition members found many opportunities during the afternoons and at the week-end for relaxation in a social yet educational atmosphere on excursions—details of which were available to them in an Excursions Guide prepared by the Local Committee. With such a wide variety of industry at hand and with such ready access to some of the finest country in the British Isles, and with so many generous hosts ready to open their doors to members of the Association, it was not surprising that such a variety of excursions were available. Members' appreciation of all that they saw and learnt during these visits was greatly enhanced by the Local Committee's generous gift of a copy of the most handsomely produced survey entitled 'The Glasgow Region', prepared for the occasion of the Association's visit to Glasgow. Lord Boyd Orr, in a review in *The Scotsman*, described the survey as 'not the least of the benefits to be derived from the visit of the Association to Glasgow'. 'The book', he said, 'gives a comprehensive and well-balanced picture of the City and its environment and will have a prominent place in the literature dealing with the past and present progress of Scotland's greatest City.'

Members' intellectual and social activities were complemented on Sunday, August 31, when they were privileged to attend Divine Service in the Cathedral Church of Glasgow. Sir Alexander Fleck and Lord Boyd Orr read the lessons and Dr. Nevile Davidson preached the sermon. Dr. Davidson said that for too long in popular thought, and perhaps especially among younger people, it had been assumed that it was necessary to choose between a scientific and religious view of the universe and that the two were incompatible and mutually exclusive. Rightly understood, the discoveries of science illuminated and confirmed the beliefs of Christian thinkers.

It is pleasant to be able to close this account of the Meeting—which concluded at midday on Wednesday, September 3—with the words of a leader-writer in the *Glasgow Herald*:

For whatever may be the Conference's long-term results, it has already had its customary effect on the layman of imprinting at least temporarily something of the logical and ordered pattern of scientific thought upon the rougher and more random fabric of humanity. . . . All that remains is to wish our guests 'God speed' and to hope that

when they reassemble at York a year hence, their discussions will prove no less stimulating and educative to their hosts than they have been in the week now past.

The Association's own sincere thanks to their hosts in Glasgow were expressed in the following words at a final meeting of the General Committee on the Wednesday morning:

At the close of the 120th Annual Meeting the General Committee resolve to place on record its sincere thanks for the reception accorded to it by the City and University of Glasgow. The generous co-operation of the Rt. Hon. the Lord Provost and the Corporation of the City of Glasgow, the Chancellor and Principal of the University, and the Director of the Royal College of Science and Technology, and the thorough preparations made by their staffs and other local officers have been deeply appreciated.

The British Association most cordially thanks the Court of the University of Glasgow for their hospitality to the Association, for the use of their buildings, and for the valuable and untiring help given by the University authorities and staff.

The Association also has to extend most cordial thanks to the many scientific, educational, commercial and industrial institutions in Glasgow and the neighbourhood for co-operation and facilities so generously provided for meetings, excursions and visits.

The Association is deeply grateful also to the students of the University of Glasgow for their invaluable help and to the Boy Scouts for the willing and unobtrusive service which they rendered and which so greatly assisted the smooth running of the Meeting.

THE DIRECTORY OF NATURAL HISTORY AND FIELD STUDY SOCIETIES

THE Council of the British Association for the Advancement of Science have, at the invitation and with the financial backing of the Carnegie United Kingdom Trust, prepared a new edition of *The Directory of Natural History Societies* which was first published in 1948 by the Amateur Entomologists Society.

The Directory, which will be published during January 1959, covers archaeological, astronomical, biological, botanical, geographical, geological, meteorological and zoological societies, both national and local amateur bodies—and other cognate societies. The information given for each society is listed under the following headings: title and address, name and address of Secretaries, aims and objects, conditions of membership, amenities, meetings, publications and affiliations. Societies are arranged alphabetically under the main headings of natural history, archaeology, archaeology and natural history, societies with general interests, geology, astronomy, and meteorology. The arrangement of the societies within the sections is strictly alphabetical according to the titles supplied by the Secretaries. There is a final geographical reference section in which the names of the societies are listed alphabetically according to counties. This geographical section has been compiled so that naturalists moving from one district to another may be able to get into touch with others having similar interests.

The Council of the Association hopes that the publication of the *Directory* which contains information about some 800 societies will stimulate field studies throughout the country and, by increasing the possibility of co-operation between professional and amateur scientists, will make a real contribution towards our understanding and appreciation of the world in which we live.

Copies of the *Directory* may be ordered (17*s*. 6*d*., plus postage) from The Secretary, British Association for the Advancement of Science, 18 Adam Street, Adelphi, W.C.2. A limited edition of interleaved copies will be available at £1 1*s*., plus postage.

NATURAL HISTORY AND EXPERIMENT IN ARCHAEOLOGY[1]

by

DR. P. A. JEWELL

THE subject of this talk concerns that borderland of investigation where the interests of biology and archaeology overlap: it is a field from which both sciences may gain new and intriguing material. Biology intrudes into archaeology in two quite different ways. On the one hand are the remains of animals and plants found associated with the relics of prehistoric man, that tell us of his environment and economy. These are the bone and antler, grain impressions and pollen, that can be studied in the museum or laboratory. On the other hand, every site occupied by prehistoric people has been subject, with the passage of time, to a process of denudation and disguise, in which biological agencies have played an essential part. Here lie the problems of interpretation that every field archaeologist must face.

It is to the latter aspect that Darwin made a major contribution in his work on the role of earthworms in the denudation of the land and the burial of buildings. Indeed, to gain some of his information he became an amateur archaeologist and carried out minor excavations at Roman villas and at Stonehenge. But most important perhaps, if for no other reason than the example he set, were his experiments to give quantitative expression to the rates at which both large and small objects may become buried and at which silting and denudation occur.

Darwin's experiments are remarkable both for their simplicity and duration. He wanted to know what quantities of soil were brought to the surface of a field by the activity of earthworms, and at what rates small objects would become buried. Accordingly, in 1842 he spread cinders and chalk on the fields about his house, planning to dig them up at some future date. It was not until 1871 that he again turned his attention to the experiment and explored these fields with shallow trenches to measure how far down the lumps had been buried. That Darwin contained his curiosity for twenty-nine years is a tribute to his patience, but we have a satisfaction that he could not have hoped to attain, in that we now know what has happened on these fields in the course of a hundred years. For this we must thank Sir Arthur Keith, who reinvestigated the site in 1941. Apparently Darwin had not anticipated this eventuality for he left no record of exactly where, on his fields, the chalk and cinders were spread! It is instructive for us to compare the results that Keith obtained with the measurements Darwin had made seventy years previously. The sites of their investigations are shown in the plan of Darwin's grounds in Fig. 1.

Great Pucklands is a long field that borders the valley west of Darwin's house. It had been ploughed in 1841, the year before Darwin went to Downe, bringing a great quantity of flints to the surface. Darwin describes how, when his sons ran over the field, the stones made a great clatter. Ten years later, the field having reverted to pasture, hardly a stone was to be seen on the surface. After thirty years Darwin dug trenches and measured the depth to which the flints had become buried. He found a three-inch mould lying over the flints, and this accumulation he ascribed to the activity of earthworms removing soil from beneath the flints and depositing it as worm-casts above them. In 1941 Keith, too, dug trenches and found, somewhat to this surprise, that the flinty layer had remained apparently

[1] Lecture delivered to a joint session of Sections D (Zoology) and H (Anthropology) on 'The Darwin Centenary' on August 29, 1958, at the Glasgow Meeting of the British Association.

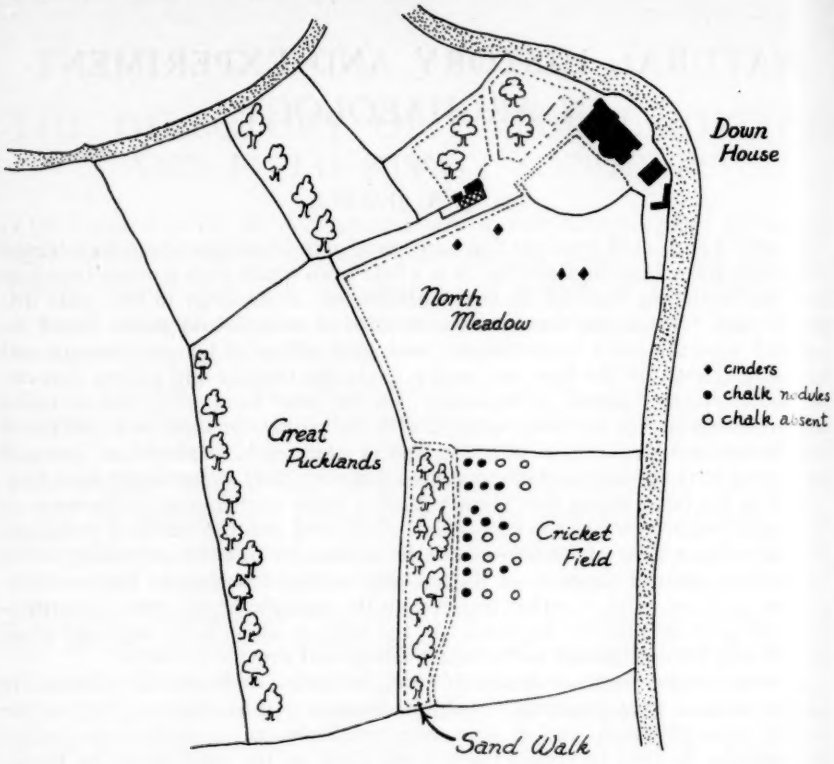

Fig. 1.—Plan of the fields about Darwin's house showing the sites where cinders and chalk were spread. (After Keith, 1942.)

stationary at a depth of three inches (see Fig. 2). Close examination revealed a feature that Darwin had not emphasised. Whilst there were signs of the snuff-coloured subsoil having been brought up above the flints, equally there were patches of dark humus deposited below them. The worms were effecting a two-way traffic in soil, different species perhaps playing different roles, for many common species of earthworm do not eject casts on the surface but deposit them in crevices below ground. Every archaeologist is familiar with the dark bands of humus that worms have carried into the subsoil, often, in fact, with a more conspicuous result than that on Great Pucklands. But on this field the densely compacted layer of flints no doubt acts as an obstruction to great earthworm activity.

Darwin's chalk lumps, spread on Cricket Field, illustrate another feature of soil disturbance. Darwin found that in twenty-nine years the lumps had sunk seven inches. Keith found that the layer of chalk had remained at seven inches, and that there was none deeper, but in addition he found another, less conspicuous line at a depth of three inches (see Fig. 2). The agent of this displacement was soon discovered. Elsewhere on the field, chalk lumps were found on the surface where they had been thrown out in recently formed molehills. Keith concluded that the chalk layer at a depth of three inches was due to mole castings that had taken place some twenty years previously. The cinders tell a similar story in that they too were nowhere deeper than the seven inches recorded by Darwin. In fact, the average depth of the mould above them today is nearer six inches (see Fig. 2), which may

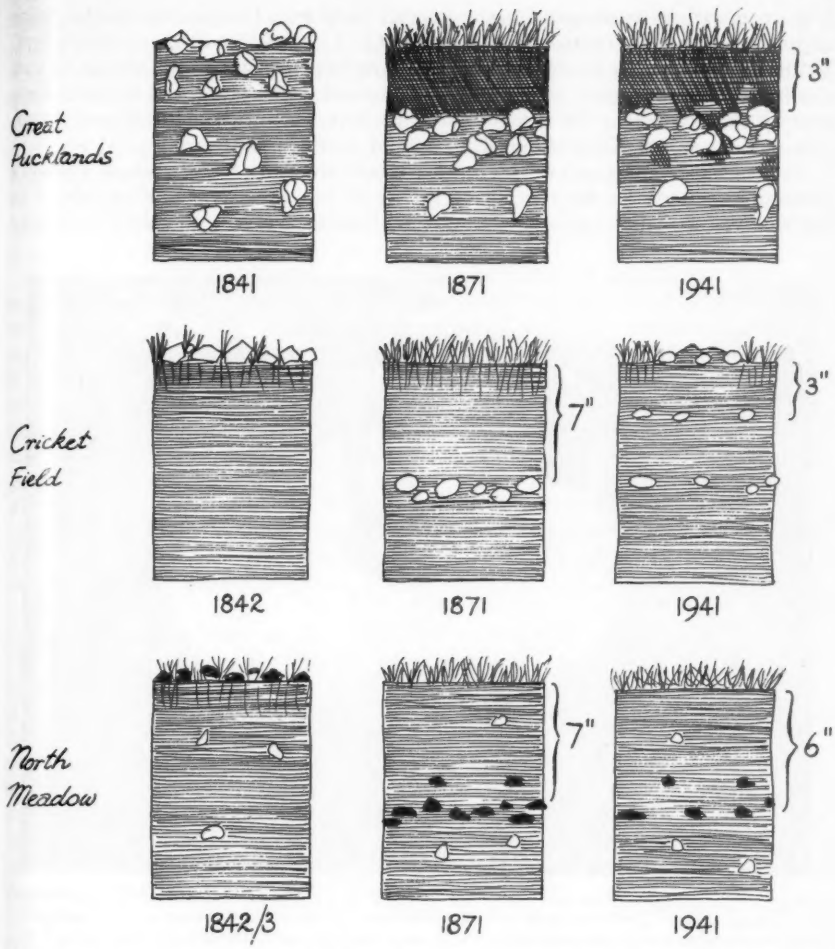

Fig. 2.—Diagrammatic soil profiles of three fields to summarise the findings of Darwin and Sir Arthur Keith.

possibly be explained by Keith having examined the profile under conditions dryer than those existing when Darwin made his measurements.

Two things emerge from this postscript to Darwin's experiments. In the first place, small objects scattered on the soil surface will become fairly rapidly buried by earthworm activity but may then acquire a relative stability of position at quite shallow depths. And secondly, intensive activity by moles can cause gross disturbance and a false secondary stratification of these small objects.

To return to Darwin's preoccupation with the rates at which objects become buried, we find that with his son Horace he set up an elaborate experiment in 1878 in order to attempt some precise measurements. A large stone with a hole at its centre, somewhat like a small millstone, was set over a copper rod driven seven feet into the ground. Movement of the stone relative to the fixed rod was then made by means of a micrometer device that could be set on the stone (Fig. 3). When I first heard of this experiment I was excited at the prospect of taking measurements

to get new data on its progress, but unhappily, as Horace Darwin records in a paper of 1901, the stone was accidentally disturbed in 1896 and no further records kept. In the eighteen years of the experiment, however, the stone was shown to sink one inch, and the records for any one year show the interesting fact that the stone rose up slightly during the winter—a feature correlated with the degree of dampness of the ground and swelling of the mould in wet weather.

Careful observation and simple measurement were the foundation of Darwin's deductions about the denudation of the land, but in addition he delighted in speculative calculation about the large-scale movement of soil, based on the data he

Fig. 3.—An experiment carried out by Darwin and his son Horace to measure the movement of a large stone. The micrometer-screw device is set on the stone and touches the top of one of two metal rods, driven deeply into the ground, that protrude through a hole in the centre of the stone. The stone is about 18 inches in diameter.

(*Photograph by courtesy of The Royal College of Surgeons of England.*)

obtained. I have attempted to follow his example in some calculations on barrow construction.

A common method of making a barrow was first to heap turves stripped from the surface of the land into a turf stack or central core to the barrow, and then to cover this with the soil and subsoil taken from the surrounding ditch. It is interesting to know what area was stripped to provide the central stack, and in order to calculate this it is necessary to make an estimate of the original volume of the turf stack. This, in turn, can be obtained by measuring the degree to which the barrow has become compacted with the passage of time. Barrows on chalk downland are particularly favourable to work with, and I have been fortunate in having the co-operation of Mr. Nicholas Thomas, who has currently been excavating Bronze Age barrows at Snail Down on Salisbury Plain.

To measure the degree of compaction of the barrow-turves a simple soil-sampler was made, like a large apple-corer, to cut soil samples of fixed volume. Samples

were taken both from the turf stack of the barrow and from the modern turf of the surrounding downland. These samples were oven-dried to a constant weight and the modern turf samples were found to weigh, on average, only three-fifths as much as the barrow turves. The modern turf contains much more organic matter than the ancient turf, of course, but in the dry state this makes a relatively insignificant contribution to the total weight. It is reasonable to infer then that the weights of the samples reflect the relative degrees of compaction of the soil. If we assume that turf in the Bronze Age was little different to its modern counterpart, then we may deduce that the barrow turf stack has become compacted to three-fifths of its original volume.

An application of the calculation can be demonstrated by data from a large twin bell barrow on Snail Down. The main features of the barrow are shown in Fig. 4. It has two mounds, each with a turf core, though with the passage of time the mounds have come to coalesce through the accumulation of detritus between them. A single ditch surrounds the two mounds, but the sequence of operations undertaken in building each one was not the same. Whilst in both the extent of the turf core had been defined by a ring of stakes, the larger stack was built on the old land surface, whereas the smaller one was dumped directly on bare chalk. Another feature revealed at excavation, and requiring explanation, concerned the weathering of the ditch. Today the ditch is defined by a wide depression in the ground, but the actual dug ditch was found to lie quite asymmetrically towards the outer margin of this depression. For some reason the inner lip of the ditch had been more heavily weathered than the outer.

The volume of the larger turf stack is 7,930 cubic feet. Corrected for compression by the factor of 0·6, this gives an original volume of 13,200 cubic feet. If we assume a turf thickness of six inches (similar to what it is today), then 26,400 square feet of ground would have had to be cleared to supply material for the stack. The area of the entire barrow platform enclosed by the outer margin of the ditch (excluding the ground under the large turf mound) is 24,120 square feet. The figures are close enough to substantiate the assertion that this was the area stripped to provide turf for the larger mound. It accounts for its monumental size and suggests that the placing of the smaller mound on the bare chalk was planned as a later part of the operation. In addition, it follows that the stripping of the berm of the barrow, but not the area outside the ditch, must have been the factor promoting the heavy weathering of the inner lip of the ditch.

Finally, on these questions of denudation of the land, I would like to turn to some observations that archaeologists have made, that have a direct bearing on our understanding of the process and rate of the formation of soils. It has frequently been observed that under barrows or other earthworks the natural subsoil and rock stands higher than elsewhere outside the earthwork. Professor Atkinson has recently gathered this information together and shown how earthworks protect the underlying rock from weathering. Knowing the period of construction of the earthwork, we have a measure of the rate of disintegration of the rocks. The data relating to chalk downland are of particular value since here, in places, are the interesting chalk heath soils whose mode of formation is a matter of controversy. They are relatively thin acid soils lying directly above chalk rock and may be residues from solution of the chalk, or may have been transported from elsewhere. The theory that they are residues has been difficult to maintain since the supposed rate of solution of the chalk would be too slow to provide sufficient material. This rate was derived from percolation data combined with the measured concentration of calcium carbonate in drainage waters. The method gives figures of something like five inches of chalk dissolved away in 3,200 years. The archaeological data, however, present a different picture. Under barrows of Middle Bronze Age date, such as those at Snail Down, the chalk has been found to stand to a height of up to twenty

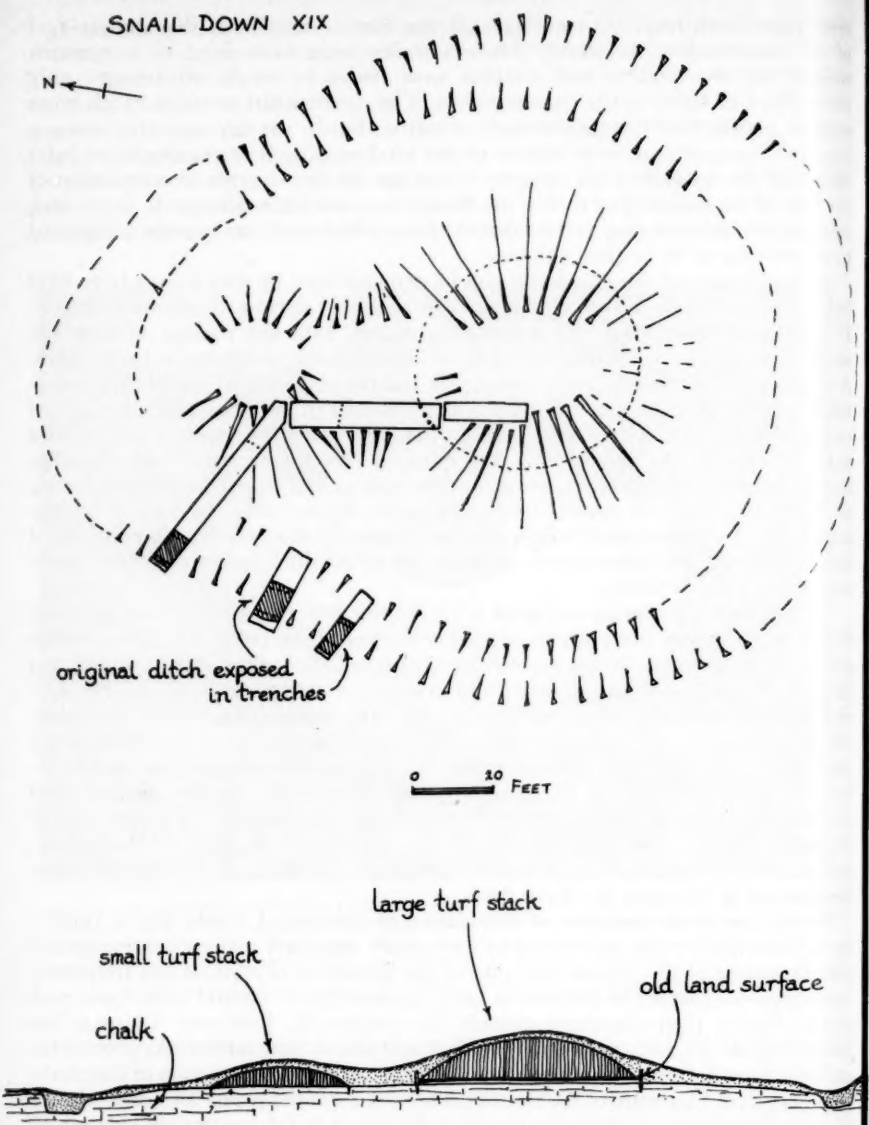

Fig. 4.—Plan and diagrammatic section of a twin bell barrow on Snail Down, Salisbury Plain.

inches above the surrounding downland. Dating the barrows at about 1300 B.C., a figure of twenty inches of chalk dissolved away in 3,200 years is obtained. This figure, I believe, puts a new complexion on the problem and makes the accumulation of quite deep soils from chalk residues a perfectly plausible matter.

To turn now to the other aspect of the overlapping interests of biology and archaeology—the finding of animal and plant remains in an archaeological context. It would be an exaggeration to say that Darwin made any personal contributions to this field, but as a point of historical interest it should be recorded that he was

clearly aware of its potentialities. In a letter to *Nature* in 1880 he draws attention to the molluscan assemblage to be found in the midden heaps that comprise the Omori Shell Mounds in Japan, and points out that they contain the shells of species no longer found in the adjacent seas. This local extinction of species within recent prehistoric times, whilst it may indicate a change in status of the species, may equally indicate a change in climate, or some other factor of the environment of interest to archaeologist and ecologist alike.

I would like to describe an unusual faunal assemblage of Bronze Age date that I have recently been examining. When excavating the barrows at Snail Down on Salisbury Plain to which I have already referred, a large number of minute animal bones were found at the level of the old land surface. The bones were those of a great variety of species—water-vole, short-tailed vole, and field-mouse; mole, common shrew and pigmy shrew; toad and slow-worm, and skylark. In places the bones were accumulated in little aggregates. There can be no doubt that they represent the prey of some raptorial bird such as the buzzard or kite. These birds disgorge the remains of a meal in the form of pellets that usually contain large numbers of small bones, often quite unaffected by the processes of digestion. It is a testimony to the ideal conditions for the preservation of bone in chalkland barrows that the minutest bones had survived, including the paper-thin osteoderms, less than one millimetre wide, that support the scales of the slow-worm. All the species identified are common in the South of England today, and all the species of mammal, with the exception of the water-vole, still occur on Snail Down itself. This was confirmed by live-trapping with Longworth traps. The water-vole alone requires special comment; the more so since its remains were the most abundant of any animal. In England today the water-vole is strictly confined to a waterside habitat, living in the banks of streams and dykes. Large tracts of Salisbury Plain, being a free draining upland, are presumably inhospitable to it, and the nearest waterway to Snail Down is the River Avon four and a half miles away. Does the presence of water-vole in Bronze Age deposits indicate more active streams and a wetter climate than at the present time? And does this evidence conflict with our idea of the rather drier climate of the sub-boreal times? Actually it need not, for the confining of the vole's habitat to the waterside may be a relatively recent development. On the Continent there is a form of the water-vole that burrows in dry fields far away from water, and this does occur at one place in England, on Read's Island in the Humber. It has been suggested that their success on Read's Island is due to the lack of competition from rabbits, rats and moles, which are not found there. This leads to an interesting speculation, for two of these species were absent from the whole of England in Bronze Age times. The rabbit was introduced by the Normans, and rats came in in medieval times. Perhaps these introduced species have restricted the range of the water-vole and forced it to abandon all but its waterside habitat.

The deductions from these pellets have taken us rather far away from archaeology, but there are two further points that do give clues to some features of barrow construction. The first relates to standing stakes, and the second to the season of the year at which the barrows were built.

The birds most likely to have made the pellets are the buzzard and kite. They like to choose a point of vantage, such as a dead tree or a stake, to which they habitually resort to disgorge their pellets. In the case of one barrow the small animal bones were found exclusively at the level of the old land surface, and were concentrated at the centre of the barrow. Here a number of large stake holes were found in the chalk, but there was no trace of the stakes having continued up through the core of the barrow. The stakes had been removed from the site, therefore, before the mound was actually built. But, if we assume that the accumulation of pellets was due to birds using the stakes, then we can deduce that the stakes were removed only shortly before the mound was built, because pellets do not survive

for long when exposed on open ground. It would seem that the stakes played some part in the sequence of events connected with barrow construction.

In the case of another barrow the pellets were strewn at the periphery of the turf stack. Here the birds must have been using the ring of stakes that had been erected to define the limit of the turf stack. Excavation showed the faintest traces of these stakes in the mound, suggesting that they had not been removed in the final stages of barrow construction. This conclusion is supported by the fact that pellet remains were found at levels above the old land surface as high as the junction between the turf core and its capping of chalk lumps.

The mammalian remains in the pellets are almost all of immature animals, young water-voles and young moles being particularly common. Such prey is most abundant in the late summer. As mentioned above, it is most unlikely that the pellets would survive long, and they would certainly be disintegrated and dispersed by a winter's exposure. This evidence points to the construction of the barrows in late summer or autumn.

Such deductions are extremely speculative, but they serve to show that natural history has a place in archaeology. The more such material that can be obtained, so the more detailed will the eventual reconstruction of the activities of prehistoric man become. For the biologist there is ample reward in any increase in knowledge of the history and past distribution of our fauna and flora.

I referred earlier on to the experiments that Darwin initiated to investigate the processes by which all structures in the ground become denuded and destroyed. The slowness of this process necessitated long experiments. The earthworks that people have built in the past have, up till now, provided material for other investigations. Nevertheless, a host of problems arise in the interpretation of any excavation that might be greatly aided by yet more detailed information. Perhaps in this Centenary year it would be appropriate and profitable to consider what long-term experiments might be initiated to further our understanding of the processes that in time destroy every archaeological monument.

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NUCLEAR POWER AND THE ENGINEER[1]

by

SIR CHRISTOPHER HINTON, K.B.E., F.R.S.

IF WE look at nuclear energy in its narrowest sense we are forced to the conclusion that all that it does is to make a new fuel available for the release of heat which can be used to generate power. In old-established and conventional practice, chemical

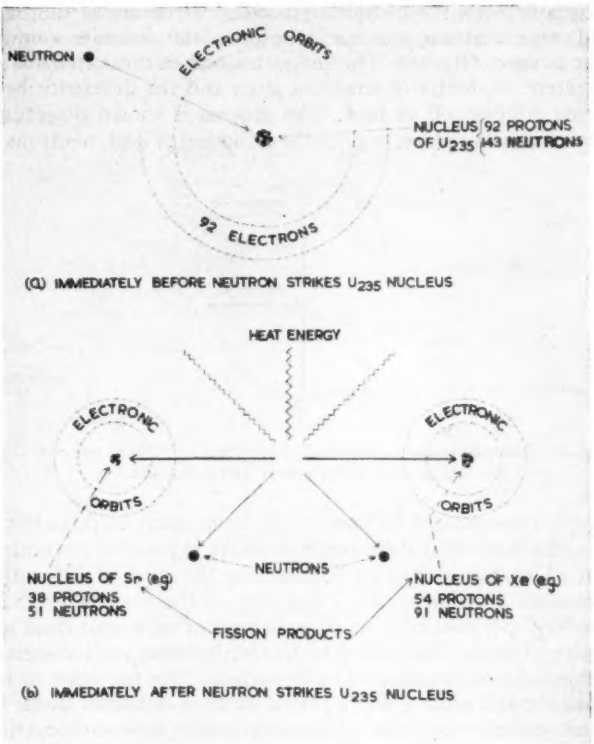

Fig. 1.—Illustration of fission.

reactions are used to release heat from matter. In burning fuels, the molecular particles are re-arranged in such a way that the energy content of the molecules which are produced in the reaction is less than the energy content of the molecules at the start; the difference between these energy contents is released as heat. It is a characteristic of chemical reactions that no change takes place within the nucleus and only the movement of the electrons in the outer orbits is affected.

In nuclear reactions, however, the arrangement of the particles in the nucleus of the atom is changed and because the binding energy in these particles is much stronger than the binding energy of the particles in the outer orbits of electrons, the energy changes which can take place are of far greater magnitude. Many

[1] Evening discourse delivered on Friday, August 29, 1958, at the Glasgow Meeting of the British Association.

nuclear changes of this sort are known to be theoretically possible and in the hydrogen bomb and the Zeta experiments which have recently been carried out at Harwell, changes are made in the nuclei of the reacting particles in which the nuclei of light atoms are made to combine so as to form heavier atoms. But it will be many years before reactions of this type can be used industrially and today, and for many years to come, the only nuclear reaction which is capable of use on an industrial scale is that in which the nucleus of one of the large and complicated atoms at the top end of the periodic table is made to split, forming two atoms of smaller size.

In nature there is only one atom in which such fission is possible, namely, the atom of uranium having an atomic mass of 235. When the nucleus of this atom is bombarded by a neutron the complicated atomic structure of the uranium atom breaks up and two new atoms, which may be any of the elements around the middle of the periodic table, are formed. The energy content of these atoms is smaller than the energy content of the initial uranium atom and the difference between these energy contents is given off as heat. The process is shown diagrammatically in Fig. 1. When fission takes place, besides the evolution of heat, neutrons are released

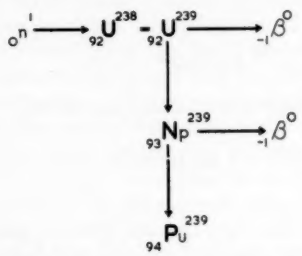

Fig. 2.—Natural uranium contains 0·7 per cent, U^{235}, 99·3 per cent U^{238} (i.e. one atom of U^{235} to every 140 atoms of U^{238}).

—the number so released may be one or may be as many as three but the average is about two and a half—and these neutrons make it possible to continue the process of fission which was started by bombarding the atom of 235 with a neutron.

Natural uranium contains only 0·7 per cent of the fissionable U 235 isotope; the remaining 99·3 per cent consists of an isotope of an atomic mass of 238 which is not fissionable (Fig. 2). The atoms of U 238, however, will absorb neutrons to form another isotope of uranium—U 239—which does not exist in nature. This isotype is unstable and after a short period of time it breaks down to form the artificial element called neptunium which again breaks down to form the stable but fissionable atom of plutonium.

By suitably exposing natural uranium metal it is therefore possible to carry out a chain reaction in which fission of U 235 is caused and in which plutonium is formed from atoms of U 238. This is shown in Fig. 3.

Because there are about 150 atoms of U 238 to every one atom of U 235 in natural uranium it is obvious that there is a statistical probability that most of the neutrons emitted by fission will be absorbed in the U 238 and will not cause further fissions of U 235. If this were allowed to happen the reaction would obviously die away, and in order to obtain a system which is capable of maintaining itself the statistical probability of causing fission of U 235 atoms must be increased. This can be done by reducing the velocity of the neutrons. When they are emitted they are travelling at very high speeds—some at speeds of about one-tenth of the speed of light—but by bedding the uranium in a suitable material (which is called a moderator) in which the atoms are of suitable size, the neutrons which are emitted can be

made to share their energy with the atoms of the moderator in such a way that these neutrons are slowed down to velocities which correspond with the temperature of the moderator. These velocities are of the order of 2–3 miles per second and the neutrons are then said to be moving at thermal velocities. Neutrons which are moving at thermal velocities are less likely to be absorbed in atoms of U 238 and more likely to cause fission of U 235.

To do this the uranium is arranged in the form of rods within the moderator, these rods being laid out in a lattice with a suitable pitch.

There is, of course, a loss of neutrons from the system both by useless absorption in the materials of construction and by loss from the surface. This surface loss naturally depends on the surface area of the assembly, whereas the number of neutrons available within the assembly depends on its volume. Because the volume is increasing on a cube law whereas the surface area is increasing only on a square law the availability of neutrons for continuing the reaction can obviously be improved by increasing the size of the assembly. If this assembly is below a certain size the loss of neutrons will be so great as to make the reaction die out; if the assembly is made sufficiently large there will be spare neutrons. All practical reactors must be above the critical size so that there are spare neutrons available. These spare neutrons are used to build up the intensity of the reaction and when this has reached a sufficient level the excess neutrons are absorbed by inserting rods of a suitable material into the reacting core in order to control the level of activity, and the heat from this reacting system can then be used to raise steam for generating power in exactly the same way that heat from conventional fuels is used.

Fig. 3.—Chain reaction forming PU^{239}.

Although in a narrow sense nuclear power has only introduced an alternative fuel, much more than this has been done since 1946 when the Atomic Energy Organisation of the United Kingdom was first formed within the Ministry of Supply; a whole new and complicated industry has been created. The first factory, which was built at Springfields, was for the extraction of uranium from its ore and the subsequent purification of the uranium salts and their conversion into metallic uranium which was enclosed in cans for insertion into the reactors. After irradiation in the atomic piles these fuel elements contained plutonium which was needed

for defence purposes, and a reduced quantity of U 235. They were treated in chemical plants in which the plutonium was extracted in an impure form and subsequently purified and converted into ingots of metal. The solution, containing fission products, was concentrated by evaporation and put into storage, while the uranium, with its depleted content of U 235, was purified. Before it could be re-used in reactors this depleted uranium had to be re-enriched in its fissionable isotope and this was done in the diffusion plant which was built at Capenhurst. Fig. 4 illustrates in a very simple form the main steps in the cycle.

In the ten years between 1946 and 1956 the problems of these ancillary plants were inconceivably greater than the problems involved in the design and construction of nuclear reactors, and of all the difficulties which we met during those years I believe that those connected with the design and construction of the chemical

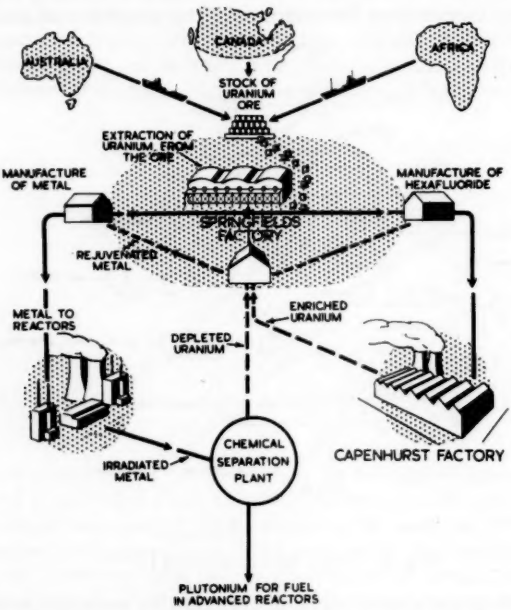

Fig. 4.—Diagram of flow of uranium through manufacturing processes.

separation plants were by far the greatest (Fig. 5). But these plants are likely always to remain behind the scenes; it seems probable that they will continue to be operated by the Atomic Energy Authority and as each plant is able to process the materials required for, and produced by, several reactors, the number of these plants is likely to be limited. It is in the development and use of the reactors themselves that public interest has been mainly concentrated and it is in this field that the greatest development is likely to take place in the future.

One of the reasons why the reactor problems presented the least of all our difficulties in those early days was that in designing them, we were able to proceed in a stepwise way towards the evolution of advanced systems, whereas in the development of the ancillary processing plants we were bound to jump directly from laboratory-scale work to the design and construction of full-scale units planned to meet the requirement for many years ahead. When, in 1946, we started to design the graphite-moderated, air-cooled experimental reactor at Harwell, we had the benefit of the experience which had been gained through participation in the design

of the Chalk River experimental pile, and the fact that even today this is probably the best general purposes research reactor in the world is a tribute to the skill and ingenuity of Newell and Ginns who were mainly responsible for its engineering. A sectional view of the reactor is shown in Fig. 6. It consists simply of a mass of graphite moderator built up from accurately machined blocks in which rods of uranium enclosed in aluminium cans lie in a suitably spaced lattice. The heat of

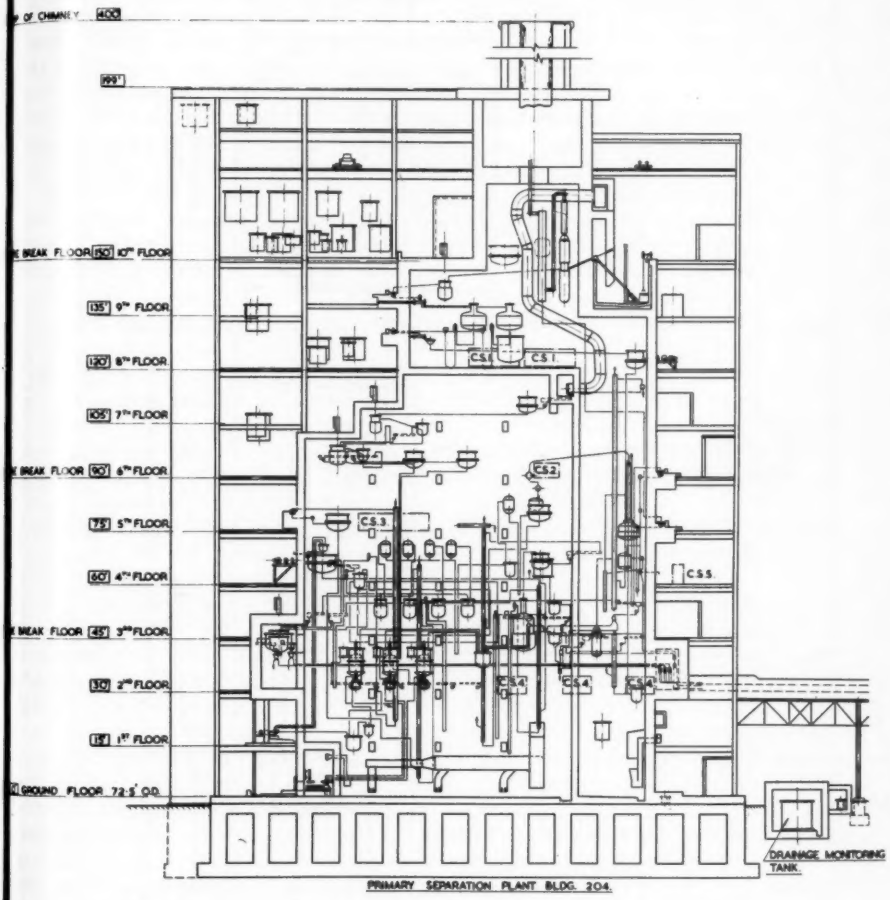

Fig. 5.—Cross-section through chemical separation plant, Windscale.

fission is removed by blowing air over the uranium rods and the heated air is passed through filters and discharged to atmosphere. The reacting core is enclosed within a concrete biological shield and control is exerted by moving rods of boron steel (which is an effective absorber of excess neutrons) into the reacting core through one of the biological shield walls.

The experience which was gained in designing and building BEPO was extremely valuable. At first it is worrying to feel that one is designing a complex and expensive plant where, if breakdown occurs, it is impossible to get access for repairs. This feeling led to a standard of accuracy in the construction of BEPO which was not justified. Indeed, the most important experience which we gained in carrying

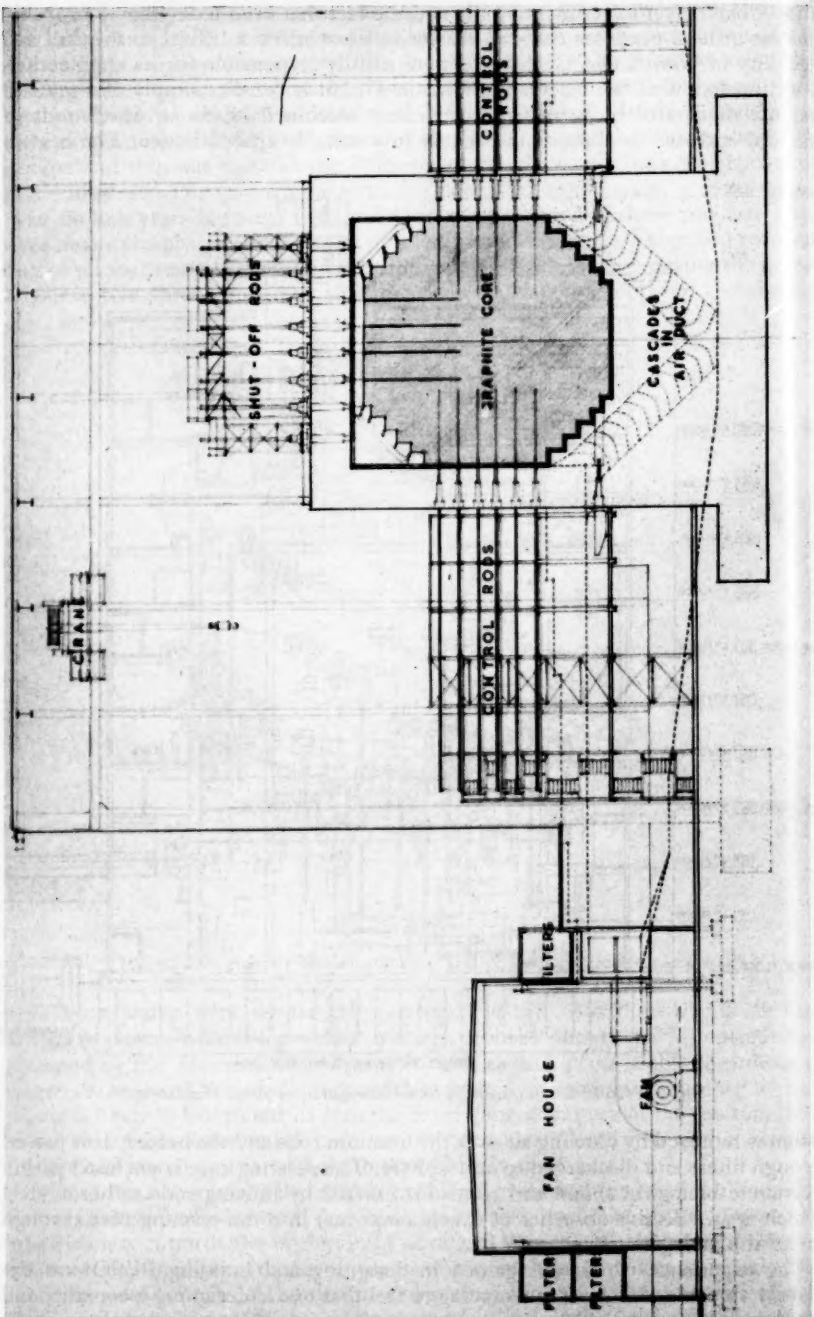

Fig. 6.—Longitudinal section of BEPO, Harwell.

out this project was the knowledge of how far it was possible to depart from the theoretical requirement stated by the scientist while still meeting his practical requirement. This is the basis of all engineering art.

Our next commitment was to build the large reactors required for plutonium production for defence purposes. It was at first intended that these should be of a design similar to those at Hanford in the United States, i.e., thermal reactors, graphite-moderated and water-cooled. But at that time it was not possible to build reactors of this type which had inherent stability. During operation they might become super-critical and disperse radio-active fission products over a fairly large area of the countryside. Because of this, the Americans had located their reactors in a remote situation, and had adopted safety distances from towns of various sizes. There was no evidence at the time to suggest that these safety distances could be relaxed, which made it difficult to select convenient sites in a densely populated country like Great Britain.

We knew that during the war the Americans had wished to build a large gas-cooled reactor but were discouraged by the difficulty of obtaining the huge blowers that were required. The attractions of gas-cooling were, however, so great that we started an intensive study of the problem. We came to the conclusion that by putting fins on the cans of the fuel element and by compressing the coolant gas, we could design gas-cooled graphite-moderated reactors which would not only produce plutonium but would at the same time generate electrical power. Power could not be generated, however, unless the temperature of the gas leaving the reactor was reasonably high, and the problems of achieving these temperatures involved more research than we had time for. We realised that by temporarily sacrificing our objective of generating electrical power and by using air at atmospheric pressure as our coolant, we should be able to build a reactor for the production of plutonium which would be inherently safe and which would not need to be built in a remote locality. This led to the construction of the Windscale reactors which are, in fact, scaled-up versions of the large Harwell experimental reactor which we had already built.

Fig. 6.—Longitudinal section of BEPO, Harwell.

The scale of the construction can be judged by the fact that the chimneys are over 400 ft. high and the total weight on the foundations was about 58,000 tons. But, apart from their scale, they represented only a reasonable step forward from the practice which had been evolved in designing the Harwell experimental reactor. The most important development as compared with Harwell was in the introduction of burst slug detector gear. It was only at a comparatively late stage in design that the need for this gear was established and the technique for detection was evolved. This technique involves taking samples of the exit air from all of the channels in the reactor so that, if a defect develops in any of the fuel elements, the fission products which escape can be deposited electrostatically on a wire which is then monitored by a Geiger counter. It was impossible to sample the exit air from all channels without introducing moving parts to the reactor. The guiding principle in all of our design philosophy had been to avoid any moving parts within the active zone, and the decision to use this air-sampling gear was a difficult one, but in spite of it the essential simplicity of the design remains.

Meanwhile, we continued to work on the problem of developing a gas-cooled reactor for the production of useful power. By 1953 we had arrived at a practical scheme. In that year there was an additional demand for plutonium for defence purposes and we decided that this requirement should be met by building graphite-moderated gas-cooled reactors which would produce electrical power as a by-product, and this was done on the Calder Hall site.

In the Calder Hall reactors the heat of fission is removed from the fuel elements by cooling them in pressurised carbon-dioxide gas instead of with atmospheric air as in the Windscale reactors. The uranium fuel elements are arranged vertically

in the mass of the graphite moderator and the whole of the reactor core is enclosed in a steel pressure vessel which is more than 40 ft. in diameter. Hot gas leaving this vessel is passed through ducts to the heat exchangers in which it gives up its heat to water and so generates steam which is used in conventional turbo-generators to make electric power. The carbon-dioxide gas cooled in this way passes through other ducts to the blowers which force it back once more into the reacting core. The system is shown diagrammatically in Fig. 7.

When the construction of the first Calder Hall reactor was only in its early stages we felt certain that it could form the basis of the programme for the large-scale development of industrial nuclear power and this scheme was published in the White Paper of 1955.

Up to that time all of our nuclear power plants had been designed, built and operated by the Atomic Energy Authority, although all the component parts had been manufactured by industrial firms. It was decided that this was the appropriate stage at which industry ought to be brought in and trained in reactor design so

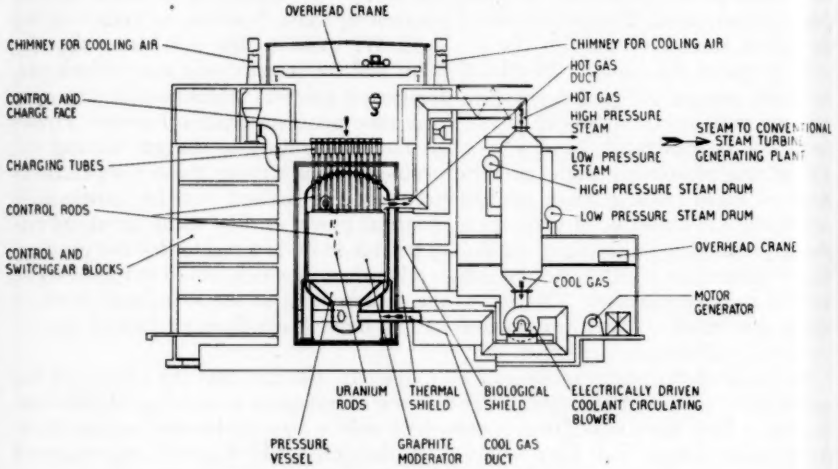

Fig. 7.—Cross-section of Calder Hall reactor.

that the Atomic Energy Authority could proceed with its main task of developing more advanced types, while the industrial firms built the reactors which would be used by the electricity supply authorities. Four of these industrial power stations are now being built and a cross-section of a typical one which is under construction at Bradwell is shown in Fig. 8.

The electrical output of this and the other industrial reactors will be far greater than that of the Calder Hall reactors. In this particular case it will be seen that the pressure vessel which contains the reacting core has now been made spherical and is of considerably greater diameter, a larger core is thereby made possible and heat transfer is improved by using a higher pressure in the circulating carbon-dioxide. But essentially the principles of design of this reactor and of the other reactors which are being built for industrial use are identical with those which were evolved for Calder Hall and which have now been in satisfactory and uneventful operation for two years.

When I gave the Clayton Lecture to the Institution of Mechanical Engineers in February 1954 I said, 'In looking at the Windscale piles you will be struck by their essential simplicity. This is, indeed, the key to pile design. The problems as initially presented to the designers rarely looked simple, sometimes they looked

almost frightening in their difficulty and more often they were frightening in their high content of the unknown. The main skill in pile design has been in reducing such problems to terms in which they could be interpreted into engineering structures so simple, so well understood, that even the unknown ceased to give cause for alarm.' This is true today of all good reactor design; in looking at the designs of Calder Hall and of the industrial reactors the most striking feature is once more their simplicity, and simplicity in reactor design must always be achieved. Simplicity is the essential of all good design.

Having looked at the course of reactor design since it started in 1946, let us try to predict its future. We have seen that in our earliest reactors though we released large quantities of heat, we were not able to use this heat for the generation of a useful electrical power because we could not recover it at a sufficiently high temperature. By the time that the design of Calder Hall was put in hand developments in research had made it possible to achieve temperatures which enabled us to

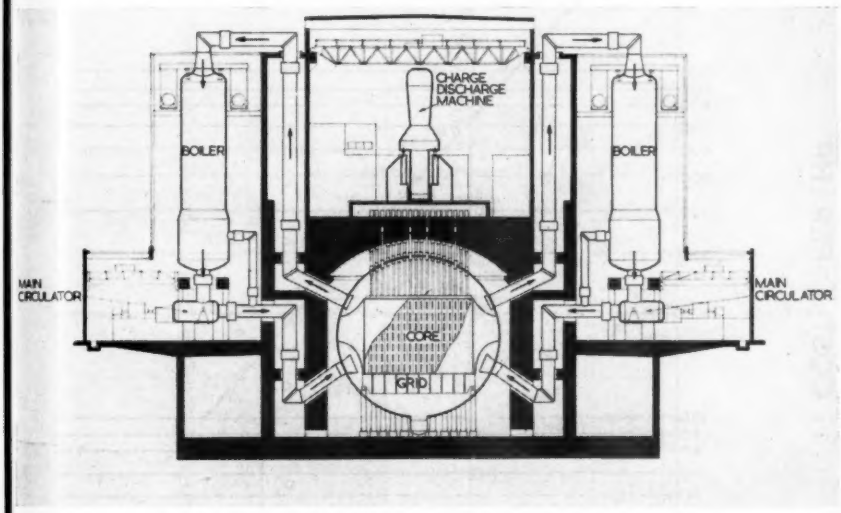

Fig. 8.—Cross-section through reactor buildings, Bradwell.

generate useful power, but these temperatures are still low by comparison with conventional power plant practice.

If we look at the history of these conventional power plants we find that their capital cost has steadily fallen with the passage of years. This is shown in Fig. 9. More than anything else this reduction in the capital cost of steam power plants has been linked with the rise in the initial temperature which it has been possible to achieve in the steam cycle. This rise in initial temperature with the passage of time is shown in Fig. 10. The limit has been imposed by different factors at different times; in the earliest days it was controlled by the pressure which could safely be sustained in cast-iron vessels, later it was limited by the performance of cylinder-lubricating oils in reciprocating engines, but for the last forty years it has been controlled by the metallurgy of the materials available for superheater, steam pipe and turbine construction. This rise in the initial temperature in the steam cycle has made it possible for higher working pressures to be used and this in turn, operating hand in hand with other developments, led to bigger boiler and turbine units and it is this growth in unit size and rating which, more than anything else, has brought down capital costs. But besides bringing down the capital cost of

conventional steam plants the higher top temperatures which have been achieved in the steam cycle have increased the efficiencies which have been achieved. James Watt's engines consumed 6 lb. of coal per horse-power hour; today the modern

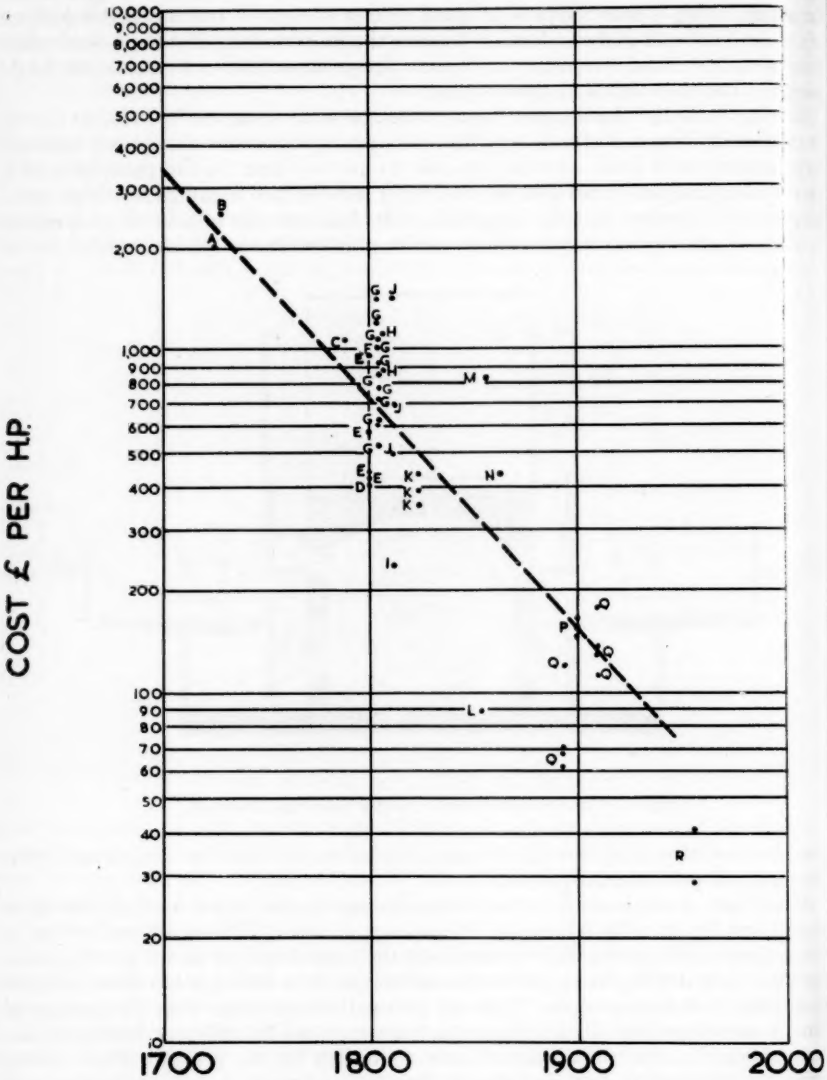

Fig. 9.—1954. Equivalent capital cost of steam power stations, £'s per horsepower.

steam generating plant consumes only ¾ lb. of coal per horse-power hour, and this rise in efficiency has sprung almost entirely from the rise which has been possible in the initial temperatures in the heat cycle.

We have already seen that when the Windscale reactors were built we were not able to recover the heat of fission at a high enough temperature to enable us to

generate any useful electrical power. The considerations which held us down to these low temperatures were the possibility of reaction between the graphite moderator and the cooling air and, secondly, the possibility of trouble with the fuel elements. These fuel elements consisted of rods of uranium metal about one inch in diameter enclosed in aluminium cans. Aluminium was used as the canning material mainly because it has a low cross-section for neutron absorption; magnesium was considered as an alternative material but was rejected because of the possibility that the cans might catch fire and cause great damage. But while the use of aluminium had the advantage of avoiding this difficulty, it had the corresponding disadvantage that it was known that aluminium formed a metallic compound with uranium and that this chemical reaction proceeded more rapidly as the operating temperature rose, and it was mainly this consideration which held us down to the temperatures which were used in the Windscale piles.

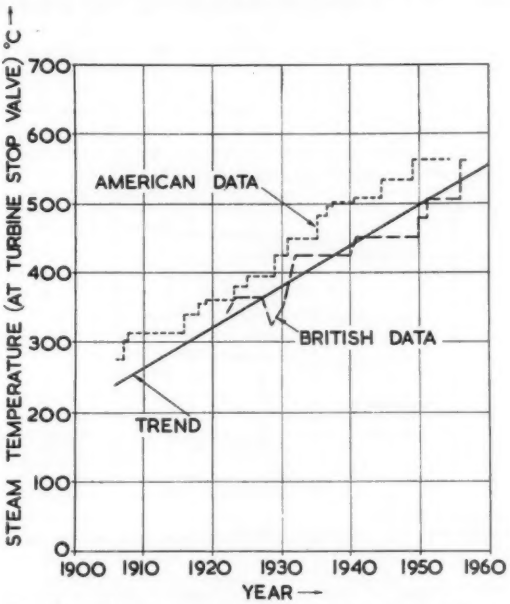

Fig. 10.—Rise of steam temperature with passage of time.

The construction of the Calder Hall reactors, in which the heat of fission was recovered at a sufficiently high temperature to enable it to be used to generate useful electrical power, was made possible mainly by researches which overcame this difficulty. An alloy of magnesium was developed which made the possibility of the ignition of the can much more remote and in addition the use of carbon-dioxide as a coolant instead of air still further reduced the risk of fire. Since that date the experience which has been acquired in the fabrication and use of fuel elements of the Calder Hall type has made it possible to assume in the design of the reactors for the electricity authorities that it will be possible to achieve temperatures slightly higher even than those which are used at Calder Hall. We find, then, that the short history of nuclear power shows an upward trend in the top temperature which can be achieved from our reactors in exactly the same way that we find that the much longer history of conventional power plants shows an upward trend in the top temperature of the heat cycle. This upward trend is shown in Fig. 11.

Besides the top temperature which can be achieved in the cooling gas leaving the

reactor there is another major factor in reactor design which affects the capital cost per kW of power produced. This is the rating of the fuel elements. If the rating of the fuel elements can be doubled (that is to say, if twice as much heat per second can be produced from each kilogram of uranium in the reactor) then obviously twice as much heat and approximately twice as much power can be produced from a reactor of given size and the capital cost per unit of heat output will thereby be reduced. There are many factors which affect the fuel element rating which can be adopted but of these the most important is the temperature at the centre of the uranium fuel element. The heat of fission is generated throughout the whole mass of uranium and the heat released in the centre of the fuel element must be conducted to the surface for removal in the stream of cooling gas. This flow of heat

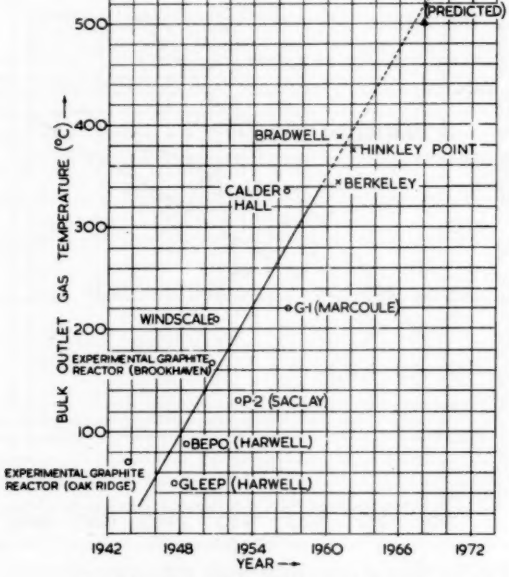

Fig. 11.—Upward trend in gas temperatures.

demands a temperature gradient and it therefore follows that the temperature of the centre of the uranium rod must be higher than the temperature at its surface. The higher the rating of the fuel element, the greater must be the temperature gradient across it in order to conduct heat from centre to surface. Higher fuel element ratings therefore mean higher centre temperatures in the uranium and, when this is accompanied by the higher surface temperatures which are necessary in order to enable us to achieve higher temperatures in the exit cooling gas, we soon find that we are operating at uranium temperatures which are likely to be troublesome. But Fig. 12 shows how fuel element ratings have risen in the past, and if reactor technology is to continue to develop in the future this trend must be continued.

We are therefore faced with the conclusion that improvement in industrial nuclear power plants can only be made possible by increasing top temperatures and the heat ratings of our fuel elements and that this demands fundamental develop-

ment in fuel element design. These developments involve research which is largely of a metallurgical character and so once again in the nuclear field we find that, as has so often happened in the development of conventional power plants, the engineer must rely on the metallurgist for research and development work before he can make real progress. In my 1954 Clayton Lecture I said, 'The limiting factor in reactor design is the performance of the fuel element and this is likely to be the case for many years to come.'

No great improvement in the top temperatures can be expected while we continue to use magnesium alloy canning material. It will be necessary to use either stainless steel, which is an uneconomical absorber of neutrons, or some material having a low neutron cross-section and a high melting point, such as beryllium. But beryllium is an expensive metal and one which is costly and dangerous to handle. It will be necessary to minimise the quantities which are used and this will mean higher ratings so that the maximum amount of heat is obtained from every

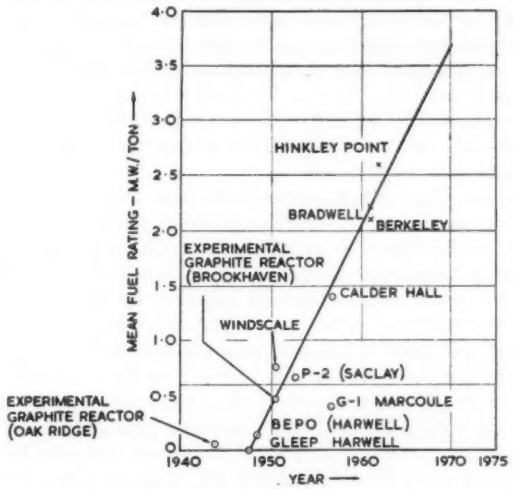

Fig. 12.—Rise in fuel element rating with passage of time.

fuel element. With high ratings it will be impossible to employ uranium rods of the diameter which are at present used and even if the fuel elements are made with smaller dimensional cross-sections it is probable that the ratings which are adopted will be so high as to give rise to fuel element centre temperatures which would be dangerous with metallic uranium. It will therefore be necessary to use either a ceramic or a cermet fuel element and this will additionally be necessary because the steps that will have to be adopted in order to achieve the requisite top temperatures and heat ratings will make the fuel elements far more expensive, and we will require a far higher burn-up of the fissile material than can be achieved with metallic uranium in order to bring their cost per unit of electricity generated down to a reasonable level.

These developments involve an immense amount of difficult research and development work, but it is essential that this work should be carried out expeditiously and successfully. The cost of electricity generated in the nuclear power plants which are under construction is estimated to be between 0·66*d*. and 0·7*d*. per unit. Based on current prices, power will be produced from the best conventional plants which are being built today at a cost of only 0·54*d*. per unit and it is therefore obvious that the present nuclear power plants can only be justified as the

foundation for improving nuclear technology. But in calculating the nuclear power cost of 0·66*d*. to 0·7*d*. per unit it has been assumed that these nuclear power plants will be used for base load only and will not be asked to take any share of the peak load. In a conventional power plant only about one-third of the cost of each unit of electricity generated arises from capital charges, the other two-thirds arising from fuel and operational charges. In the nuclear power plants which are at present being built this proportion is approximately reversed and two-thirds of the cost of each unit of electricity generated arises from capital charges, while only about one-third arises from fuel costs and operating charges. It is therefore obvious that if the present nuclear power plants are asked to take a share of peak load and therefore to work at a lower load factor, they will be placed at a great disadvantage as compared with conventional plants. This was not a matter of great concern at the time when the first plan for nuclear power was issued as a White Paper in 1955. That plan envisaged that by 1965 about 1,800 MW of nuclear plant capacity would be installed. At such a rate of expansion it would be possible to use nuclear power plants on base load for a considerable time. But for various reasons the plan was expanded in 1957 and now envisages an installed nuclear capacity of about 5,000 to 6,000 MW by 1966. At this rate of expansion nuclear power plants will have to carry a share of peak load by 1971 or 1972. This means that the nuclear power plants which are enquired for in 1966 and ordered in 1967 must have capital costs which are so much reduced as to enable them to compete with conventional power plants when taking a share of the peak load.

Each nuclear power plant which has hitherto been ordered has shown improvement in capital costs as compared with the previous plant, but virtually all of this improvement has arisen from straightforward engineering development of the Calder Hall design and hardly at all from basic scientific or metallurgical improvement. The field for these straightforward engineering developments must be a limited one. Beyond a certain point it will be impossible to progress unless fuel element technology has been developed to a point which will enable higher top temperatures, higher fuel element ratings and higher fuel element burn-ups to be achieved, and to meet the requirement of the expanded programme this must be done by 1966. In the Axel Johnson Lecture which I gave before the Royal Swedish Academy of Engineering Science in 1957 I examined the past history of reactor design and the future trend of development and suggested that if the rate of progress which has been achieved in the nuclear field in the past can be continued, and if the cost of coal continues to rise as it has done, nuclear power should begin to be cheaper than conventional power in the reactors which are commissioned in 1963.

There has, I think, been a tendency to assume that the forecasts in the Johnson Lecture were predictions of what would happen rather than indications of what should happen. The work which was described in that Paper was done to determine what was a reasonable target for the research and development departments and for the engineers. The results predicted can only be achieved if development continues with the same energy, skill and success in the future as in the past.

It is of vital importance that this rate of progress should be achieved. The engineering technology of the construction of nuclear power plants differs in many important respects from that of the construction of conventional plants, and the engineering capacity of manufacturers in the power plant field is being swung into the manufacture of nuclear plants to an important degree. If by the 1960s nuclear plants are not developed with capital costs so low as to enable them to compete with conventional plants when carrying a share of peak loads then we shall be faced with the alternatives of continuing to build nuclear power plants which will produce more expensive electricity than the conventional power plants that could

then be designed or of swinging the manufacturing technology back from the nuclear to the conventional field.

The expanded nuclear programme of 1957 was adopted for reasons which were considered to be good. It will, however, be a mistake not to realise that, besides involving a far greater rate of capital investment, this larger programme demands a higher rate of scientific and technological development. Progress is necessary not merely in the field of the gas-cooled reactor but also in the development of the fast reactor which, so far as one can see at the moment, is the only device which will enable us successfully to use up the by-product plutonium which is produced in reactors of the Calder Hall type. Moreover, the advance must be made with that same regard to safety in the future which has been achieved in the past; public opinion is so sensitive to nuclear risks that even a minor accident might lead to a set-back in the programme which would involve immense difficulties. The problems and the challenge of the next ten years are as great as those of the first ten years. The industrial use of nuclear power cleared its first hurdle in 1956 when Calder Hall went into operation; it must clear its second hurdle with equal success in 1966 when we must be able to build reactors whose design is so advanced, and whose capital cost is so low, that they are able to take their share in carrying peak loads of electricity.

BOOKS RECEIVED

Title	*Author*	*Publisher*	*Price*
Science in Schools	W. H. Perkins, O.B.E.	Butterworths	15*s.*
Henry Edward Armstrong	J. Vargas Eyre	Butterworths	30*s.*
Proceedings of the 8th Meeting of the International Committee of Electrochemical Thermodynamics and Kinetics		Butterworths	95*s.*
Current Trends in Heterocyclic Chemistry	Papers collected by the Chemical Society	Butterworths	30*s.*
Performance of Metal Cutting Tools	R. Tourret	Butterworths	50*s.*
Phenolic Resin Chemistry	N. J. L. Megson	Butterworths	65*s.*
Classification and Indexing in Science	B. C. Vickery	Butterworths	25*s.*
The Kinetics of Vinyl by Radical Mechanisms	Bamford, Barb, Jenkins and Onyon	Butterworths	50*s.*
Essential Fatty Acids	H. M. Sinclair	Butterworths	50*s.*
Chemistry of the Rare Radioelements	K. W. Bagnall	Butterworth	30*s.*
Strength of Chemical Bonds	T. L. Cottrell	Butterworths	32*s.*
The Periodic Table	D. G. Cooper	Butterworths	6*s* 6*d.*
Biographical Memoirs (Vol. XXXI), *National Academy of Sciences of the United States of America*		Columbia University Press Oxford University Press	40*s.*
The Effects of Atomic Radiation on Oceanography and Fisheries		National Academy of Sciences, National Research Council, Washington, D.C.	$2.00
Special Relativity for Physicists	G. Stephenson and C. W. Kilmister	Longmans, Green & Co.	18*s.*
Introduction to Electronic Theories of Organic Chemistry	G. I. Brown	Longmans, Green & Co.	15*s.*
Productivity and Social Organization—The Ahmedabad Experiment	A. K. Rice	Tavistock Publications Ltd.	35*s.*
The Dawn of Life	J. H. Rush	English Universities Press	15*s.*
The Ionosphere	Karl Rawer	Crosby Lockwood & Son Ltd.	42*s.*
Dilogarithms and Associated Functions	L. Lewin	Macdonald & Co. (Publishers) Ltd.	65*s.*
Tables of Light-scattering Functions	Boll, Leacock, Clark and Churchill	University of Michigan Press	71*s* 6*d.*
General and Inorganic Chemistry	J. R. Partington	Macmillan	60*s.*
Logic Machines and Diagrams	Martin Gardner	McGraw-Hill	39*s.*
Concepts of Classical Optics	John Strong	W. H. Freeman	80*s.*

SCIENCE AND HILL FARMING

IN THE application of science to its problems, hill farming is the 'Cinderella' of the various farming types. This is partly because its production is low, being only a little over 5 per cent of Britain's farm output. Despite this, it forms the foundation of the major part of the country's highly integrated and stratified sheep industry. As fully half of the hill farming of Britain is in Scotland, it was appropriate that at the Glasgow Meeting of the Association, Section M (Agriculture) should devote a whole session (on the morning of Tuesday, September 2, 1958) to the problems of hill farming. Professor D. S. Hendrie, Principal of the West of Scotland Agricultural College, presided, and the main paper reviewing the problems was given by Mr. A. R. Wannop, Director of the Hill Farming Research Organisation. This was followed by papers on 'Hill Land Improvement' by Dr. R. F. Hunter of the Hill Farming Research Organisation, on 'Health in Hill Flocks' and on 'The Economics of Hill Farming' by Messrs. A. L. Wilson and J. B. McCreath of the West of Scotland Agricultural College, respectively. Summaries of the papers appear below.

A REVIEW OF HILL FARM PROBLEMS

By A. R. Wannop

Hill farming in Scotland is widespread; every county except one—West Lothian—contains some hill farms, while the total area of rough grazings extends to just under eleven million acres.

In character hill farms vary enormously. At one extreme are the grassy Cheviot hills, characterised by agrostis–fescue–nardus swards, which, on the best farms, carry one ewe to two acres, and with from 2 to 5 per cent of the farm being arable ground. At the other extreme, both geographically and otherwise, are the extensive areas of the North-West Highlands, with 1 per cent or less of the land being arable, with a mixed hill herbage of heather, rushes, scirpus, sedges, cotton-grass and molinia, and only maintaining one ewe to ten or more acres. In between these two, conditions vary considerably. There are, for instance, the heavy rainfall areas of Argyll (60–100 inches), with one ewe to four or five acres and about 1 per cent of the farm arable. Across the country in the North-East, with its drier, dominantly heather-clad hills, which carry one ewe to three or four acres, there may be as much as 8 or 10 per cent or more of the farm as arable land. One thing is common, however, throughout Scotland—sheep are the dominant livestock on the hill and the flock *lives on the hill* throughout the year. Even in the North-East where turnips are fed to hill ewes in February, March and April, the ewes only leave the hill for three hours or so each morning. In this area ewes may also lamb off the hill, but they return as soon as the lambs can walk readily. This feeding of turnips and lambing off the hill is exceptional, and at the most applies to only 5 per cent of the hill ewes of Scotland.

SOCIAL PROBLEMS

In considering hill farming, one cannot overlook the fact that the social problems are equally as important as those of a technical character. Some degree of isolation is a feature of nearly all hill-farming areas, and the provision of roads, houses, water supplies, electricity and other modern necessities is both more difficult and more costly than elsewhere. Without them, adequate supplies of shepherds and other skilled men will not be maintained in a type of farming which cannot be mechanised as can arable farming. Though modern insecticides, anthelmintics and

prophylactics have greatly reduced the labour of shepherding, and while new devices now becoming available may remove some of the drudgery of sheep-handling, work study may lead to a simplification of layouts, and contract shearing replace the one-time assembly of all one's neighbours, the handling of sheep at essential gatherings will always demand a minimum of man units.

This brief reference to social problems would be inadequate without mention of the Hill Farming and Live Stock Rearing Acts, which have provided 50 per cent grants towards the cost of approved rehabilitation schemes. Under the Acts much has been done to provide better permanent equipment and it is estimated that almost one in two of the specialised hill farms in Scotland have taken advantage of the assistance offered. It is interesting that whereas in England and Wales the average size of farm assisted has been about 250 acres, in Scotland it has been about 1,750 acres, indicating the varying character of upland farms throughout Great Britain. It is difficult to assess how far these schemes have increased the livestock population of these hill farms, but in many cases they have arrested decline and on the whole production per ewe has risen even if ewe numbers have remained constant.

Technical Problems

A common feature of hill farms is the inherently low level of soil fertility, which, combined with elevation and rigorous climatic conditions, results not only in low output per acre but in a highly seasonal production of herbage. Though the latter may be more than adequate in quantity in summer it is mainly low in quality, since, though for two or three months it may contain enough protein and energy, it tends to be low in mineral composition. In winter it is both high in fibre and unpalatable, and the hill ewe has to range further for her reduced intake. Among livestock she is unique in that she is required to survive in winter on a diet which is frequently insufficient to maintain body weight while her annual pregnancies coincide with this period of semi-starvation. It is not surprising that many hill ewes lose from 10 to 20 per cent of their weight during pregnancy, some even more, but rather that, despite this, they continue to produce and rear a lamb three years out of four, or four out of five. This would be impossible if they lacked the capacity to build up food reserves during summer and utilise these efficiently in winter. The measure of the efficiency of this mechanism is their ability to survive, or, as it is called, their hardiness.

Hill Land Use

In considering the problems of hill farming objectively we must examine the way in which agriculturalists use hill ground. All the evidence indicates that the condition of hill grazings has been and is still slowly but progressively deteriorating in respect of fertility and of type of vegetational cover. The original fertility level was never high, but when there was some cover of deciduous trees the decline was less than now. Trees disappeared one hundred to two hundred years ago (sheep prevent their natural regeneration), and the run-off of water is quicker and greater. When to the loss of mineral and other matter in the run-off is added the annual drain in lambs, cast ewes and wool, there is bound to be a steady depletion of the natural resource, aggravated in this century by changes in husbandry due to the decline, for economic reasons, of both human and cattle populations. Over most of Scotland, cattle and sheep are no longer, as they were a century ago, herded so that they grazed some plant communities at certain seasons, and at others these were saved for later use. The decline in numbers of men has left the sheep free to graze at will, to select and overgraze the most palatable and to under-graze the coarser herbage, while the decline in cattle removed the effective grazing complement which helped to maintain a balanced sward. As a result of this selective grazing by sheep we have had a marked increase in plants such as molinia, nardus, deschampsia

and bracken, as well as in juncus and sedges. Though this change in botanical composition has not in itself lowered fertility on the hill, it has rendered the hills less productive.

Our problem is to attempt to reverse this trend and to make hill grazings more productive. Getting back cattle is a first step, and the hill cow subsidy has helped, the numbers now receiving subsidy being roughly 40 per cent over those of ten years ago. Any attempt to replace the annual drain of minerals is more difficult. Merely to put back each two or three years what is removed in the same period can be done by aeroplane, but is inadequate as a commencement. The normal hill soil is so acid that small dressings of lime and phosphate, though they may raise the mineral content of the herbage slightly, do not stimulate any visible herbage response. In quite extensive trials we have had no response to light dressings. If reasonably heavy dressings of lime are given, the follow-up can be in regular light dressings, and at that stage aerial top-dressing could play a part. Distribution of two, three or more tons of lime is not, however, economically feasible by aeroplane, and so far has only proved worth while on gently sloping and drier hills, where conventional machines can be used. But these areas are quite a slice of hill and moorland country, and deserve more attention than they get.

Winter Feeding

In attempting to improve the production of a hill farm one thinks first of improving the general level of nutrition of the livestock, and as this is at its lowest in winter, it is winter feeding of the ewe that demands priority. Lack of adequate nutrition is in general a greater limiting factor than deficiencies of trace elements or of lime and phosphates, though when the latter are superimposed on a lack of protein and energy, pathological conditions can arise.

Obviously we should use, as far as possible, the ability of the ewe to build up reserves in summer and autumn and draw on them in winter and spring, so long as we do not rely on it excessively and so sacrifice economic production. An analysis of the flock performance on H.F.R.O.'s three research farms shows that the ewes which are in best condition in the autumn wean the heaviest lambs the following summer. Good condition in this case must not be confused with very fat condition. It is exceptional for hill ewes to be so fit in autumn that ovulation is reduced and barrenness increased. Hence any husbandry practice that results in fitter ewes in autumn is an advantage. On *grassy hills* this can be helped by using cattle to keep the herbage shorter and more nutritious, so that ewes recover condition more quickly after weaning. An example of what can be achieved by cattle is seen on the Fasset hill on the Sourhope research farm. In 1951 breeding cows were introduced to this hill, which covers 250 acres and has been stocked throughout with 130 Cheviot ewes plus 30 ewe hoggets. The cows, twenty-six in number, and usually all suckling one calf each, graze the hill from May to November, being wintered elsewhere. A comparable hill is grazed by sheep only. As a result of this mixed grazing the herbage is better controlled, the sheep stock has improved, ewes are heavier in autumn, and there are more and better lambs. Before the introduction of cattle the annual sale of weaned lambs, cast ewes and wool off this hill amounted to 6,000 lb. in weight. Now it is 7,500 lb. In addition to this increase there is also an annual live-weight gain of at least 7,000 lb. in the calves, between May and their sale as weaned calves in October. While such a marked increase in total production is possible on a good hill of this kind, it would be wrong to assume that the same is possible elsewhere. It is also more costly to produce the 7,000 lb. of calf flesh than the same weight in sheep, because cows are much more costly to winter than ewes, but it has been profitable in this case. Some hills, of course, are not good for cattle, and on others cattle can do little good, but these are few, and on most hills cattle in suitable numbers can benefit both ewes and lambs.

Feeding on the Hill

The simplest method of increasing nutritional standards on the hill in winter is by supplementary feeding. Traditionally the hill farmers dislike supplementary feeding of ewes except for giving hay in storm. They maintain that feeding encourages ewes to be lazy, to lie about waiting for food instead of ranging the hill in search of palatable herbage, and in general is antagonistic to the qualities that make up hardiness. Believing that this is an important problem on which information is needed, we have been feeding ewes on the hill on each of our three hill stations during the last three winters. Comparisons have included hay, turnips and concentrates, and while under hill conditions three years is too brief a period from which to draw conclusions, some tentative observations may be made.

1. In the first two winters of feeding, the weather was reasonably mild and the spring early, so that ewes which received supplementary feeding and produced only single lambs did not have greater mortality in their lambs or wean significantly heavier lambs than those not fed. On the other hand, ewes producing twins did wean significantly heavier and more lambs.
2. In the third winter, with its very hard conditions and cold, late spring, fed ewes not only lost fewer lambs at birth but had heavier lambs at six to eight weeks old, up to which age they are largely dependent on milk, and at weaning.
3. Provided normal shepherding is practised, feeding moderate quantities of concentrates in cube form has not stopped the ewes ranging the hill.
4. The need for additional energy appears to be as important, possibly more important, than additional protein. Unfortunately, efforts to find out just what the ewe eats from the hill, both in quality and quantity, have proved negative to date.

So far, supplementary feeding has been for six to eight weeks before lambing, as suggested by the work at Cambridge and at the Rowett Institute on feeding pregnant ewes. This work was not done under hill conditions, and when we start feeding towards the end of February the ewes have already lost probably 10 lb. or more in weight since pregnancy began, in a ewe weighing 100 lb. in November. We need to know what would be the result of preventing any weight loss by feeding from, say, early January, and we are trying to do this.

Hill Improvement

The other approach to better winter nutrition is by improvement of the hill herbage. One's first response is to think of ploughing and reseeding, a technique now well understood. There is scope for this on hill farms, and possibly 250,000 acres could be done economically. Some would be one-time arable land, now part of the hill. Much would be on the drier, dominantly heather-clad lower hills and moorland areas in the east and north-east of Scotland. Many farmers have already shown what is possible, but they have too few imitators. There are associated animal problems, such as hypocalcaemia and hypomagnesaemia, and where peat-land is involved, copper deficiency may occur, but it can be diagnosed and treated.

Ploughing and reseeding is, however, limited in its scope on true hill ground. Unless the area can be fenced and utilised for special projects such as wintering ewe hoggets or shearlings and can be controlled by cattle grazing or used for conserving winter fodder, then the heavy outlay cannot be recovered. For much hill land, any attempt at improvement must in the meantime be restricted to surface treatment involving some or all of surface cultivation, liming, fertilising and seed distribution. We have nearly a million acres that could be profitably treated in this way, but research is still needed into each aspect of such improvement, as well as into its effects on the economy of the hill farm.

Even when all areas that might respond economically to surface treatment have been considered, there are still vast stretches, in fact nearly all the higher lying land, which are unlikely to give a return for efforts to increase their fertility but which might be improved by altered grazing and management methods. My colleagues are engaged on ecological studies on the various components of a hill sward, and also on a study of the grazing preferences of sheep, about which Dr. Hunter writes later.

Heather and Bracken

It is impossible to refer to all the major hill plants, but two—the beneficial heather and the harmful bracken—must be mentioned. Most farmers agree that a proportion of heather on a hill is good. The young growing tips are highly nutritious, while Brynmor Thomas has shown that it is highly mineral efficient—more so than the other main constituents of hill plant communities—and is therefore valuable in the diet of hill sheep, which tend to lack an adequate mineral supply. It is also valuable in storm in that well-grown heather can be reached through snow when grass tends to be completely buried. On the other hand, too much heather is a drawback and provides an inadequate diet in winter. Just what is a reasonable proportion is not known, but it will vary from district to district. While we can reduce the heather by overgrazing and by either surface treatment with lime, fertiliser and seeds or ploughing and reseeding, we do not know how to encourage it or introduce it where none is present. Where there is a large proportion of heather, sheep cannot control it by grazing, and unless it is burned, it becomes overgrown, less productive and less attractive to sheep, especially lambs. Hence the practice of rotational burning. Recently the advocates of burning have been confronted by work by the staff of the Nature Conservancy, which appears to show that burning of heather has the effect of greatly accelerating the normal but slow loss of fertility. Even if this is fully confirmed by work we have in hand, the farmers' problem is that unburnt heather progressively declines in stock-carrying capacity and any saving in fertility through non-burning would be outbalanced by a decline in production. Our programme of research includes the study of methods of heather management by both burning and grazing control to ascertain the best combination of productive growth and of fertility conservation.

Bracken has long been a developing menace on hill ground. The decline in both the cattle and human populations of hill areas during this century is partly responsible. Until quite recently the effective control has been cutting rather than bruising, as shown by Professor Braid and his colleagues of the West of Scotland Agricultural College. A series of co-operative trials in Scotland over a five-year period has confirmed these earlier findings, and showed that cutting was not only quicker than bruising in reducing the bracken to a negligible level, but that a longer period was likely to elapse after cutting before renewed treatment became necessary.

Naturally, in an age of chemical control of weeds, bracken has not escaped attention, and the most promising material seems to be dichloroproprionic acid. Much research is still needed, however, before the full implications of its use on the hill is understood, especially in regard to the follow-up treatment necessary to restore a sward most effectively and also in respect of its economics. Aerially sprayed chemicals would have the great merit of achieving 100 per cent kill and so effecting a permanent benefit.

Infertility

When one examines the lambing percentages of hill flocks one might assume that infertility in ewes is a serious problem. It is difficult to give an average lamb crop,

i.e. lambs marked compared with ewes at mating, for Scotland as a whole. In the Cheviot hills and in the east of Scotland it is around 90 per cent: in the north-east, where turnips are fed, it may be 110 per cent, but in the west it varies between 60 and 80 per cent, with a large number around 65 per cent. Nationally it may be 75 per cent. If we take the worst areas and try and ascertain the causes of a low lamb crop at weaning, we find that about 10 per cent of ewes were actually barren, due either to failure to mate or to conceive, or to reabsorption of the foetus. In a normal season, however, about 90 per cent of the ewes are carrying lambs two weeks before lambing is due to begin and the final 65 per cent or so is a measure of the losses at lambing and subsequently. Exact figures are difficult to acquire for ewes lambing on the hill, but possibly one-third of the losses are due to difficult lambings or are lambs born too weak to survive unless the shepherd can help them immediately. A further third do not survive the first week, and the remainder die before weaning. The losses after birth are due to a variety of causes, including drowning, foxes and tick-borne diseases. Where a shepherd has to cover an area of two to four square miles each day, it is impossible for him to cover the ground speedily each morning. Lambing in a limited area, if it can be arranged, would save many lambs. The problem becomes the economic one of whether the increased lamb crop covers the cost of producing it. At the Lephinmore hill research station, we have found that it does. On the Mid-hill hirsel, where there are 220 ewes, the average lamb crop at marking time (six weeks) up to two years ago was just over 65 per cent. For the last two years it has been almost 90 per cent, and this has been achieved by fencing off 120 acres at the foot of the hill and lambing in this enclosure, as well as by supplementary feeding for six to eight weeks before lambing.

This brief review is a very inadequate treatment of this subject. It has dealt with problems as they confront the hill farmer, but has not mentioned shelter, wool, performance testing or hogget wintering. Moreover, it has tried to be realistic. It is only too easy to be romantic about the part that hill land might play in feeding the nation, but one must admit that though there is scope for the application of science to hill farming and for increased output, especially on the lower and more accessible hills, the law of diminishing returns operates very quickly in hill improvement, and in some seasons nature imposes restrictions which rapidly turn a farmer's romantic dreams into nightmares.

HILL LAND IMPROVEMENT

By Dr. R. F. Hunter

The eleven million acres of land occupied by hill farms in Scotland are very variable and can be roughly divided into just over half a million acres ploughable and the remainder unploughable. It is from the ploughable area that we can expect the greater part of any increase in production, but knowing this does not solve the problem of utilising the much more extensive unploughable areas as effectively as possible. How can we improve their utilisation ? To consider this we must examine the two main factors over which we have some control—livestock and vegetation.

Livestock

It is frequently said that hill pastures are deteriorating through lack of cattle grazing and that grazing with sheep alone starts or accelerates deterioration. This is perfectly correct if we do not apply it to hill pastures in general but to those of a certain vegetational composition.

The preferences of sheep and cattle are not identical, and Table I indicates the degree of preference they show for different types of vegetation.

TABLE I

	Bent–fescue	Molinia	Nardus	Heather	Flushed bent–fescue with *D. caes.*	Dry bent–fescue with *D. flex.*
Cattle .	++++	++	+	+	+++	+
Sheep .	++++	+	+	+++	+	+++

It can be seen that in some circumstances cattle grazing can be complementary to sheep grazing and in other cases competitive. Competition occurs where the pasture is composed of swards for which sheep and cattle have the same degree of preference. Where the preference varies they can be complementary, and in these cases cattle grazing improves swards not favoured by sheep by encouraging the species favoured by sheep.

The utilisation of hill pasture is also to some extent affected by the breed of sheep employed. It has been said that Blackface sheep will eat heather more readily than Cheviot sheep, but it may be that the use of Blackface sheep at the lower stocking rates found on heather moors is a reflection not only of physiological and nutritional differences between them and Cheviot sheep but also of behaviour differences.

We have had an indication in our work on sheep behaviour of an unexpected and perhaps important feature in their behaviour. This is that the utilisation of a hill pasture, the spread and distribution of grazing over it, is determined not only by the vegetation and the preferences of individual sheep but also by a herd or flock factor, the sheep distributing themselves not only in relation to vegetation and shelter but also in relation to each other.

In a study to determine if the concentration of grazing varied seasonably we found that the pattern remained the same throughout the year, although different areas of the pasture were used, different plant communities were favoured at different times of the year, and great differences occurred in the availability of grazing throughout the year. We have calculated the data for one year only (1957), so the result has to be treated with caution, but within the year studied there is no ambiguity in the results—the pattern of concentration is influenced by some herd behaviour factor. I suggest that the importance of this lies in the necessity to marry the gregariousness, the herding behaviour of the sheep, to the type of ground, and where this is not done, then the sheep must be herded to achieve it.

VEGETATION

In addition to controlling the type of stock to achieve the best utilisation of the pasture, we can also change the vegetation to achieve the same object. In considering this course we have to appreciate in the first place that we cannot alter more than a part of it. At a grazing intensity of 2·5 acres to the sheep, we cannot afford to improve much unless really spectacular increases in productivity result or the cost per acre is insignificant, neither of which yet appears possible on hill pastures.

If we can only change a proportion, then the problem is what to change, and the principles to observe are the achievement of good vegetational balance, the correct topographic siting of the improved areas and the selection of vegetational types for

improvement which will give the greatest increase in utilised improvement. This is, of course, on unfenced and almost un-shepherded grazings. To illustrate the idea of good vegetational balance consider a predominantly heather hill as an example. Improvement of the agrostis–fescue on such a hill is in my opinion a waste of effort. Improvement should be directed towards changing part of the heather sward into grass.

By correct topographic siting I mean that improved areas should be sited with respect to shelter and should be dispersed over the pasture as a whole in fairly small blocks.

It has long been the practice to improve what is most improvable, that is the bent-fescue swards. It may be that this is not the best procedure on unfenced grazings and that better results in utilisation and distribution of grazing would be gained by upgrading the poorer swards (nardus, heather and molinia), but this point requires further study.

There remains the question of cheapening improvement so that it becomes more feasible on true hill grazings.

What we want is a herbicide which will kill undesirable grasses and by reducing competition encourage the desirable ones, or even a non-persistent, non-selective herbicide, following the use of which we can introduce suitable grass and clover seeds either by surface seeding or by sowing from the air.

This is not so impracticable as it sounds, as we have some evidence that Dalapon and T.C.A., according to the rate employed, show some selectivity between nardus and *Holcus mollis*, and after spraying with them at higher rates and then harrowing we have been able to get a good take from grass and clover seeds surface sown on the mat of dead grass.

HEALTH IN HILL FLOCKS

By A. L. Wilson

(*Veterinary Investigation Officer*)

The systematic investigation of sheep diseases began in Scotland in 1921 with the founding of the Animal Diseases Research Association. Since then progress has been remarkable, and it is in the realm of disease control that the greatest advances in hill sheep farming have been made during the past thirty years.

The modern hill sheep farmer practises preventive medicine probably on a wider scale than any other class of livestock owner, the reason for this being the system under which the sheep are kept. The ewes remain on the hill during their entire productive life and only the lambs ever leave it—to spend their first winter from October until the following April on a lowland farm. Such a system means that the flock has to be gathered and brought into the steading for normal husbandry operations like dipping, docking and castrating the lambs, shearing and the various vaccinations and anthelmintic treatments. The programme of disease control must therefore be one that is capable of being fitted into the normal gatherings, and this fact must dominate all the preventive treatments that are recommended in the future. At present hill farmers can quite easily fit in the vaccinations for louping-ill, lamb dysentery and braxy, together with anthelmintic treatments, into the normal gatherings, but a difficulty always arises when additional inoculations are recommended. The solution of the problem lies in the development of mixed vaccines since they would prevent two or more diseases at one vaccination and would also reduce the number of gatherings. In addition to the use of mixed vaccines there is no reason why several operations cannot be combined. For instance, ewes could be vaccinated, dosed with phenothiazine and dipped all on the same day at the gathering that occurs a fortnight before lambing. While many diseases are capable of

control, there is still a considerable death-rate in young lambs during the first six weeks of life, and these deaths are usually classified in the broad category of black loss. A survey carried out on eleven Blackface farms revealed that although the number of ewes in lamb ten days before lambing was 91·5 per cent, by June the lambing percentage had fallen to 78·7, and at weaning time in September to 73·5. So far as helminth parasites are concerned, much knowledge has become available within recent years. Not the least important discovery was that nematode parasites lay more eggs in spring than at any other time, producing the so-called 'spring rise' in worm egg output. Since sheep are infested by picking up infective larvae that have developed from eggs laid by the female parasites harboured by the same or other sheep, it follows that the control of parasites is basically one of preventing a build-up of larvae on the pasture. To this end the adult worms in the sheep should be killed by phenothiazine given at strategic times, and in hill sheep the ewes should be treated before the 'spring rise' occurs. Considerable economic loss is still caused by the liver-fluke, and the enormous number of fluke-infested livers seen in the slaughter-houses during winter and spring must reflect an appreciable degree of impoverishment in the animals from which the livers were removed.

Of the trace elements in sheep, more has been written about copper and cobalt than any others. Apart from the association of copper and swayback in lambs, insufficient is known about the importance of this element. It is significant, however, that a high incidence of swayback often follows a heavy liming programme, especially on marginal farms. Compared with copper, there is a large volume of literature on cobalt pine. Hitherto, it has been impossible to prevent pine on inaccessible hill ground because the interval between gatherings is too long to secure the continuous intake of cobalt required for the production of vitamin B_{12}. Recently, Australian scientists have produced a heavy cobalt pill which is given by mouth and will supply the sheep's cobalt requirements for eighteen months at least. Experiments are being carried out at present to test the efficiency of the pills under Scottish conditions. Hypomagnesaemia is the most important of the major element deficiencies and has become increasingly prevalent especially in cast ewes grazing on improved marginal land. Mention must be made of Johne's disease because it is being diagnosed more frequently than ever before. The only satisfactory control at present is the slaughter of infected sheep.

The above-mentioned diseases are those that cause the greatest loss. Their pattern has changed little over many years, probably because the environment of the sheep has not changed greatly in the same period. Any sudden alteration in the sheep's environment could, however, alter the whole disease picture. Thus, improvement of hill pastures may well increase the incidence of pulpy kidney disease, while a heavy liming programme could easily increase the hazard from swayback. Uncontrolled grazing after re-seeding might predispose to parasitic disease, while hypomagnesaemia may follow any improvement in grassland. These problems, though they can be prevented, are more likely to occur on marginal farms since they are the farms on which improvements can more readily be carried out.

Finally, it has often been postulated that the number of sheep diseases is increasing while many farmers have asked if they could stop vaccinating after having done so for many years. It is true that the number of clinical entities has increased simply because better methods of diagnosis have separated diseases that were previously regarded as one condition. Then again, diseases like lamb dysentery, pulpy kidney disease, blackquarter, braxy and black disease are all caused by bacteria that form spores that can remain in the ground in a dormant but viable state for years. For this reason alone it is essential to continue vaccination. The tick-borne diseases, too, could only be eradicated if the tick itself is eradicated, and at present it is more economical to prevent and treat the diseases than to attempt to kill off all the ticks.

THE ECONOMICS OF HILL FARMING

By J. B. McCreath

Scope of Hill Farming

No less than 71 per cent (11 million acres) of the total agricultural land area of Scotland is classified as rough grazings, in contrast to the equivalent figure for England and Wales of 17 per cent. It is not surprising, therefore, that hill sheep play a very important part in the land utilisation of the country. Nationally, the main reason for the importance of hill sheep farming is the vital contribution it makes to the stratification of the whole sheep industry and to the specialisation within it.

At December 4, 1955, some 2,270,000 hill ewes qualified for hill sheep subsidy, or almost exactly two-thirds of the total ewe population of Scotland. Not all of these were, however, on hill sheep farms. In the report of the Department of Agriculture for Scotland, 'Types of Farming in Scotland', a hill sheep farm is defined as one where about 95 per cent of the total acreage is under rough grazing and permanent grass, and where the main enterprise is the production of store sheep and wool. By this definition, some 65 per cent of the ewes qualifying for subsidy are contained on hill sheep farms proper; or approximately 1½ million ewes on some 6 million acres of rough grazing. The number of such farms is surprisingly low—just over two thousand, or 6 per cent of all full-time farms in Scotland. The fact that they cover as much as 40 per cent of the total agricultural land surface, however, lends them a particular economic and social significance.

The number of employees on these hill farms in June 1947, including all family labour but excluding farmers and their wives, was some 4,700, or 4 per cent of the total agricultural workers in Scotland. No more up-to-date figures are available, but the numbers at present are probably in the region of 4,200.

Store Sheep, Wool and Cattle

In a normal hill farming year with an average lamb crop at marking of 70 per cent, the 1½ million hill ewes would leave, after allowing for flock replacements, some 500,000 lambs for disposal. Approximately 90 per cent would be wether lambs mainly sold as stores for fattening on low-ground farms. The surplus ewe lambs (10 per cent) plus the annual draft of cast ewes suitable for further breeding would form in large measure the foundation stock for other types of sheep enterprises in the foothills and lowlands.

The total weight of the Scottish clip in 1957 was 21 million pounds, or 28 per cent of the United Kingdom total. Hill wools, Blackface and Cheviot, contributed over three-quarters of the Scottish clip, while Blackface alone made up well over one-half of the country's total wool production.

On the individual farm—especially on smaller units where they are virtually essential to increase output—hill cattle are proving very useful under the special incentives prevailing at present. From a national standpoint, however, on hill sheep farms, *as defined*, their numbers and contribution must be very small in relation to the total beef cattle population of Scotland.

Average Financial Return

The figures given below are taken from the accounts of thirty-one farms—all producing Blackface lambs—situated in the counties of Argyll, Dumbarton and West Perth. The accounts are all prepared on a tenancy basis and no charge is made for the interest on capital invested.

Some Average Figures from Thirty-one Farms

Lamb crop year	1953	1954	1955	1956	1957 (Prov.)
*Management and investment income (*expressed per ewe*)	23/–	7/–	18/–	31/–	37/–
Lamb marking (per cent)	73	60	66	76	80
Store lamb price	57/–	48/–	58/–	67/–	78/–
Draft ewe price	68/–	56/–	65/–	77/–	90/–

* Net profit less estimated value of farmer's manual work.

Percentage of rough grazing	97.	Size of ewe flock	900.
Stock carry (acres per ewe)	3.	Number of hill cows	12.

In considering the table it is important to remember:

1. The 1955 and 1956 accounts contained hill sheep subsidy at the rate of five shillings per ewe.
2. These are *average* figures over thirty-one farms, ranging from the small one-man unit to the farm with several hirsels.
3. The price of Blackface wool was fairly constant over the period.
4. These returns were obtained against a background of rising costs.

The most striking feature of the table is the wide fluctuation in the level of financial return and hence the need, in certain years, for the hill sheep subsidy as an 'income stabiliser'. This type of farming is very vulnerable to the effects of factors largely outwith the individual farmer's control.

The economic effects of a poor lamb crop are twofold: there are fewer lambs to sell, and, if the flock size is to be maintained, a smaller and poorer quality draft of cast ewes. To give the same total revenue, a fall of 20 per cent in the number of lambs sold would need an increase of 25 per cent in the average selling price. In a bad year one can easily get the former but seldom the latter. The number of ewe lambs normally kept for flock replacement in this area is 28 per 100 ewes, and the death-rate in lambs from marking to weaning is around 5 per cent. Thus, in 1954, *the average* lamb crop of 60 per cent was at the danger level: there was no room for culling, which is essential for maintaining flock productivity. One-quarter of those farms in 1954 actually had less than a 50 per cent lamb crop.

The prices obtained for hill sheep at auction markets are determined far more by demand than by supply; for on most hill farms the supply cannot be regulated, since the lambs and draft ewes must be sold before the onset of winter. This point is illustrated by the figures for 1954 and 1957—in 1954, supply down, prices down; in 1957, supply at a high level, prices at a record level.

Over the four years 1953 to 1956, the proportion of total revenue derived from subsidies and grants averaged 10 per cent. The same item expressed as a percentage of the management and investment income averaged 52 per cent. Thus it is evident that without support of this kind many of the smaller units (one-third of all hill sheep farms have less than 400 ewes) would have had an unsatisfactory return even over this relatively prosperous period.

The average management and investment income over the five-year period was twenty-three shillings per ewe per annum. Although the tenancy capital required to take over this type of farm at today's prices may well be higher, over the five years £10 per ewe is a fairly realistic average. At twenty-three shillings per ewe, the average annual return on tenancy capital would be 11·5 per cent after meeting all expenses other than management.

What of the Future?

Factors which, 'if the cold war gets no hotter', are most likely to affect the hill farmer, are:

On the debit side—

1. Wages are not going to fall (approximately one-third of the total expenditure at present).
2. The upward adjustment in rents has still to come.
3. The removal of the premium on hill wools.

On the credit side—

1. Price Review policy is still emphasising mutton and beef.
2. The prices of these end-products are guaranteed and some share is passed back to the store producer.
3. The various production grants are guaranteed for some time ahead.
4. The hill sheep subsidy is in reserve for very bad years.
5. The recent reversal in money policy should be of help in the short term.

Having regard to the relative prosperity of the present and the measure of Government assistance available, the time would seem opportune for carrying out long-term improvements which are so essential for the future stability of the industry.

CHARLES DARWIN IN SCOTLAND[1]

by

DR. W. E. SWINTON

MUCH has already been written about Charles Darwin's two years as a medical student in Edinburgh and there are several sources of information. *The Autobiography* (see references) gives a brief and not entirely accurate account of the period It may be noted in passing that the footnote (p. 46) by Francis Darwin refers to the *Edinburgh Weekly Dispatch*, May 22, 1888. This should be the *Edinburgh Evening Dispatch* of the same date. It goes on to refer to the *St. James's Gazette* for February 16, 1888, but this is only the first part of the article which is continued on the following day, Friday, February 17. The most substantial account was given by Prof. J. H. Ashworth under the title 'Charles Darwin as a Student in Edinburgh, 1825–7' in *Proc. royal Soc. Edinb.*, **55,** pt. II, pp. 97 *et seq.*, 1935. There are omissions even in this fine account.

Darwin's diaries, now preserved in Cambridge University Library give occasional references to his field observations but have no information about his life in the University. The University records of the period are poor and the published papers of the Plinian Society have understandably meagre reports of a personality then scientifically undeveloped.

Charles Darwin entered the University, that is he signed the matriculation register as 'Charles Darwin—Shropshire', on October 22, 1825, being No. 84 of the book. He was then 16 years and 8 months old—young, but certainly not exceptionally so in a Scottish University. He was accompanied to the University by his brother Erasmus. Charles was entered for the year in the classes of anatomy, chemistry and materia medica only. The class lists of those days were the property of the respective professors, who took them away and the lists with the Darwins were thus lost.

Charles and his elder brother did much together. One of their first actions was to deposit their £1 to join the University library on October 25. In the session Charles borrowed twenty-one books, including Good's *Study of Medicine*; Pemberton *On diseases of Viscera*; Young's *Philosophy*; Fleming's *Philosophy of Zoology*; Kerr and Forster volumes on entomology; W. Wood on *Insects*; Brookes's *Conchology* and Newton's *Opticks*. He never borrowed a novel from the library, but he did read Boswell's *Johnson* a volume at a time. Charles took more books out of the library in that one year than any other student except his brother, who borrowed forty-one!

Their reading habits appear to have kept the brothers busy and contented for there is no evidence that they took part in any of the student activities. They were together in lodgings. The footnote on p. 46 in *The Autobiography* already referred to says, 'He lodged at Mrs. Mackay's, 11 Lothian Street'. *The Evening Dispatch* is more precise, for it states that Charles lodged at Mrs. Mackay's, 11 Lothian Street, four flights of steps up, probably in the left-hand flat of the second floor, adding that Lothian Street is more famous for the fact that de Quincy lived there! No. 11 Lothian Street is even depicted in an unsatisfactory line drawing in the newspaper. Ashworth, on the other hand, says 'his rooms were in a top flat in 21 Lothian Street (in which, about twelve years later, lived John and Harry Goodsir and Edward Forbes), less than two hundred yards from the entrance to the University'.

Today, Lothian Street is gone and the site of the Darwin brothers' lodging is part of the fossil galleries of the Royal Scottish Museum.

[1] Paper read to the Assembly of Corresponding Societies on Thursday, August 29, 1958, at the Glasgow Meeting of the British Association.

Whatever pleasure Charles Darwin had in reading in his lodgings is not known but he makes it clear that he found no pleasure at all in many of his classes. It is known that most of the classrooms were cold and draughty and the students were consequently allowed to wear hats and coats during the lectures. In *The Autobiography* he writes (pp. 46–7), 'The instruction at Edinburgh was altogether by Lectures and these were intolerably dull, with the exception of those on Chemistry by Hope. . . . Dr. Duncan's lectures on Materia Medica at 8 o'clock on a winter morning are something fearful to remember.'

Hope on Chemistry was immensely popular and it was on Hope's own suggestion in 1826 that the Senatus decided he should lecture on Chemistry to 'ladies as well as gentlemen'. As to Duncan, whose materia medica class included dietetics and pharmacy, there are other views. He was apparently an odd character and an account of him in *Lapsus Linguae, or the College Tatler*, tells that he lectured on the hips of the Hottentot Venus, on how to beat eggs, grate potatoes, light lamps and ring bells, and an unfortunate experiment on making a soufflé is described. All this and materia medica too, at 8 a.m. on a winter's morning, probably demanded an audience more tolerant than Darwin seems to have been.

A more serious criticism is Darwin's on his professor of anatomy. 'Dr. Munro (*sic*) made his lectures on human anatomy as dull, as he was himself, and the subject disgusted me. It has proved one of the greatest evils in my life that I was not urged to practise dissection, for I should soon have got over my disgust; and the practice would have been invaluable for all my future work.'

A nearly contemporary account of the Monro anatomical class (based on Monro secundus) by his rival John Bell was

> in Dr. Munro's class, unless there be a fortunate succession of bloody murders, not three subjects are dissected in the year. On the remains of a subject fished up from the bottom of a tub of spirits are demonstrated these delicate nerves which are to be avoided or divided in our operations; and these are demonstrated once at the distance of a hundred feet—nerves and arteries which the surgeon has to dissect at the peril of his patient's life.

It is clear that Darwin's professor, Alexander Monro (Monro tertius) had no more advanced techniques but there was the rival school, which Charles Darwin could have attended, had he been as enthusiastic as he indicated and as many of his fellow students did. The immediate successor to Bell in this rival anatomical class was Barclay, who is said to have dissected with such enthusiasm that dogs fled in terror at his approach. Knox, who began to lecture soon after Darwin came to Edinburgh, had a class of 500. Charles Darwin could thus have shared the prizes of Burke and Hare had he been really interested in dissection.

In November 1826, Charles Darwin returned alone to his studies. He did not join the library in this season, so presumably in the absence of his brother he felt impelled to take more part in the student activities.

He was 'booked' in this session for 'The Practice of Physic and Midwifery', yet all he speaks about in *The Autobiography* are zoology and geology. Both these subjects were taught by Robert Jameson, professor of Natural History for fifty years. Darwin calls Jameson's lectures 'incredibly dull', but other distinguished men have spoken highly of him, and certainly he had enough pupils who became distinguished naturalists. As Professor Ashworth has pointed out, the detailed syllabus of Professor Jameson's lectures for 1826 is preserved and although Darwin says nothing of the zoological series it is known that they were very complete. Jameson began with the natural history of Man and followed by describing the chief classes of animals. Sir Alexander Grant (Principal of the University, 1868) has written that Jameson's classification was 'far more scientific than that of Walker'.

It is not unimportant that Jameson concluded his course with a short series of

lectures on the philosophy of zoology, the inaugural lecture to the series being on 'The Origin of the Species of Animals'. This might well have had a more stimulating effect on the young student than Charles Darwin was inclined to remember when he came to write his autobiography.

Whether Darwin attended Jameson's lectures through the influence of fellow students he met at the Societies, or whether he joined the Societies as a result of attending the lectures cannot now be said, but in this second session, in marked contrast to the first, he was quick to have himself put up for election for the Royal Medical Society and the Plinian. His application for the Royal Medical was presented on November 10, 1826. He was elected on December 1 and immediately appointed to the Museum Committee, a post which he resigned on the 29th of the same month. It was not, presumably, because of the onerous nature of the duties, for apparently the committee did not meet, did not report, and kept no records during those twenty-eight days. Darwin's interest in this Society was not notable. When at the height of his fame, on February 8, 1861, he was elected an honorary member, forty-nine voted in his favour and two anonymous members voted against the honour.

The Plinian Society loomed much larger in his life. This Society was created in 1823 and became extinct in 1841. The meetings were held in an underground room, next to the Old Societies' Hall at the south-east corner of the University old building, and later formed part of the janitor's house.

If the premises are thus lost, many of the proceedings remain. Charles Darwin was proposed for membership on November 28, 1826, by Messrs. Browne, Coldstream and Fife, three of the five chairmen for the year. The society met weekly. At the next meeting, that of December 5, Charles Darwin was one of the five members elected to council. This must be an indication of his known interest in natural history, partly through his conversations with other students and largely because of his walks and talks with members of the teaching staff and other naturalists, such as Dr. R. E. Grant (afterwards Professor of Zoology in University College, London), Messrs. Coldstream, Kay, Hardie, Browne and Fife, some of them, of course, his sponsors in the Plinian Society.

Darwin missed only one meeting of the Society in all his membership, that of February 20, which was a purely business meeting to revise the Society's rules.

He spoke on every occasion on which some zoological subject was discussed:

He was interested on December 11 in 'A communication on the various purposes for which a vacuum is applied in the animal kingdom'.

On December 26 he commented on a paper by Mr. Browne 'On the Natural History of the Cuckoo'.

On January 16, 1827, Mr. Ainsworth read a paper on the 'Principles of Natural Classification', in which the author stated that:

(1) All classes to be natural must be founded on the first attributes of life.
(2) All orders must be founded on functions and not on organs.
(3) All genera must be founded on the appearance of the organs performing the functions.
(4) That all specific characters being originally natural the more constant they are the better.

Darwin commented on this and Mr. Ainsworth replied, but there is no record of their discussion.

On March 13, 1827, he spoke at a discussion, 'Observations on the milky appearance of some spots of water in the Red Sea', which tended to corroborate some appearance in the North Seas. 'Mr. Cheek led and Darwin commented.' Cheek was leading on a paper published in *Phil. Trans.*, **62**, 1772.

On March 27 Darwin communicated two discoveries:

First: that the ova of *Flustra* possess organs of motion.

Second: that the small black body hitherto mistaken for the young *Focus loreus* (*sic*) is in reality the ovum of *Pontobdella muricata*.

On April 3, the next meeting, he presented to the Society a specimen of *Pontobdella* with ova and young. This was in 1827 and not 1826 as he says in *The Autobiography*.

At the last meeting (on April 17) which he ever attended he presented, presumably as a leaving gift, 'Barclay on the Human Skeleton'.

But his activities were not all channelled into the Society. He consulted frequently William Macgillivray, the assistant to Professor Jameson and the assistant-keeper of the University natural history museum. Darwin uses hard words about Macgillivray—'he had not much the appearance or the manners of a gentleman'. Perhaps not, but he was generous to young Darwin and gave him sea shells, and undoubtedly, as a first-class ornithologist, he must have communicated some zeal to the younger man, who is known to have had some interest in birds during this second session.

Darwin himself records that he took lessons in stuffing birds from a negro, then resident in Edinburgh, who had travelled with Waterton. He also attended occasional meetings of the Royal Society, where he saw Sir Walter Scott in the Chair, and of the Wernerian Society, where he heard Audubon lecture.

In *The Autobiography* Darwin has called the years at Edinburgh a waste of time but a good case can be made out for regarding the time as an environment that, perhaps unconsciously, predisposed his mind to the problems he was later to consider and even to solve.

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THE NATIVE PINEWOODS OF SCOTLAND AND THEIR SIGNIFICANCE FOR CURRENT FORESTRY PRACTICE[1]

ADDRESS BY PROFESSOR H. M. STEVEN
CHAIRMAN OF SUB-SECTION K*

Introduction

As the Association is meeting in Scotland, I decided to choose a distinctively Scottish subject, 'The Native Pinewoods of Scotland'. This is a topic which is of general interest because many visitors to the Highlands have seen something of them and found pleasure in them, not only in our own day but in earlier centuries, when such travellers as Timothy Pont and Thomas Pennant visited some of the pinewoods and had something to say about them. These forests have also been the haunt for more than a century of both amateur and professional botanists and zoologists, interested in the rarer plants and animals to be found in them. They are also of interest and value to the forester today, as in the past, as I shall endeavour to show. It is possible to speak to you on this subject because the Forestry Department of the University of Aberdeen has been making an intensive study from different points of view of all the surviving native pinewoods in Scotland during the past seven years, and a colleague (Dr. Alan Carlisle) and I have written a book[2] on this subject which will be published during the next few months.

The first problem was to determine what woods were genuinely native and natural, that is naturally regenerated from woodlands of like origin and backwards through successive generations. A decision was arrived at in each instance using a combination of criteria, including available historical evidence and that of the woodlands themselves. Doubtful cases were excluded. There are in all thirty-five forests, some including several woodlands, which are believed to be truly native. They have been divided into eight groups—Deeside, Speyside, Rannoch, Great Glen, Strath Glass, Wester Ross, Northern and Southern. The most northerly individual forest is at Glen Einig in Ross and Cromarty, the most southerly the scattered trees in Glen Falloch in Perthshire, the most easterly Glen Tanar in Deeside, and the most westerly Shieldaig on Loch Torridon in Wester Ross.

Before discussing the significance of the native pinewoods for current forestry practices, it is necessary to sketch in the background. I shall, therefore, say a little about first the history of these woodlands, secondly their ecology, and thirdly the morphological variations to be found in the pine in them.

Some Historical Landmarks

The native pinewoods are sometimes called the Caledonian Forest. This name was first used by Ptolemy over seventeen centuries ago and is thus hallowed by time. The evidence of pollen analysis, and for more recent times of historical records, show that in his time, in the millennia before it, as well as during the period since, the forests that stretched through the Highlands did not consist only of pinewoods but also of birchwoods, oakwoods and alderwoods. The native pinewoods, therefore, are only part of the Caledonian Forest of Ptolemy.

[1] Address delivered on August 28, 1958, at the Glasgow Meeting of the British Association.
[2] *The Native Pinewoods of Scotland*, by H. M. Steven and A. Carlisle. Oliver & Boyd. (*In the press.*)

The sequence in the development of woodland communities in Scotland during post-glacial times was similar to that elsewhere in north-western Europe. The birches first spread over the tundra in pre-Boreal times, followed by the pine. The pinewoods appear to have reached their greatest extension towards the end of the succeeding Boreal period, but even then the evidence of pollen analysis shows that birchwoods were more extensive. Already oakwood and alderwood were extending and these woodland types spread in the succeeding Atlantic period in Scotland as elsewhere. The pinewoods appear to have been more extensive, particularly in north-west Scotland, at that time, however, than elsewhere in Britain. In the succeeding sub-Boreal period pine spread over the drying bogs, but pollen analysis shows that there was no marked change in the woodland species as a whole. In sub-Atlantic time, there was an extension of birchwoods, as elsewhere, largely at the expense of alderwood, but pollen analysis shows that the pine persisted and there was a marked rise in its percentages in modern times, no doubt the result of the large-scale planting of pine during the past two centuries. Scots pine, therefore, has been a native species in Scotland for about nine thousand years and the evidence is clear that the surviving native pinewoods are the lineal descendants of the earlier woodlands. The evidence, however, gives no support for the view that the Highlands were once covered with pinewoods. They were only one of the several natural woodland communities, and of these the birchwoods have always been more extensive than the pinewoods.

Nevertheless, the native pinewoods covered larger areas in the past. As elsewhere it is almost certain that their maximum extent was in Boreal times. The decline beginning in Atlantic times was due to the competition of other tree dominants favoured by the changing climatic conditions and not man. The first human societies in post-glacial times entered Scotland about 5000 B.C., the time of the Boreal/Atlantic transition, but they were Mesolithic hunters and fishermen who had little influence on the woodlands. From Neolithic times onwards man began deforestation, but it was first in the western and northern isles, and from Bronze Age times onwards in the lowlands and eastern coastal plains that the population was largest. While there is evidence of penetration of the Highland region from early times, it was almost certainly sparsely populated in both prehistorical and historical times and it was there that the native pinewoods were located. The principal reason why remnants of these woodlands have survived until now is their relative inaccessibility, in some instances even today. The pinewoods as well as other woodland communities had to meet the timber requirements of the small communities settled in the Highlands and their grazing animals must have adversely affected natural regeneration, but the historical evidence suggests that no dramatic change in them took place until about 1600 and in some cases later when the first large-scale exploitation of their timber began for use outwith their immediate vicinity. In many instances the only practicable means of extracting the timber at that time was by river floating, as today in Scandinavia and North America and elsewhere. In many of the forests the first extensive felling took place in the seventeenth or eighteenth centuries. There is contemporary evidence that good natural regeneration followed this first heavy exploitation in some but not all the forests, and some of the resulting crops were felled during last century, in the 1914–18 war and to a less extent in the last war.

Some Ecological Aspects

The native pinewoods and the associated birchwoods of Scotland are a part of the Northern Coniferous Forest of Europe. They have close similarities to the natural forests in south-west Norway where Norway spruce (*Picea abies* (Linnaeus) Karst.) is not an indigenous species. The tree species commonly associated with Scots pine (*Pinus silvestris* L.) are relatively few in number, the birches (*B. pubescens* Ehrh.,

B. verrucosa Ehrh. and intermediates), aspen (*Populus tremula* L.), alder (*Alnus glutinosa* L. Gaertn.) along the streams, and the rowan (*Sorbus ancuparia* L.). The larger shrubs include several forms of juniper (*Juniperus communis* L.) and holly (*Ilex aquifolium* L.).

The relationship between the pine and the birches is of interest. The pattern of the communities of pine and of birch depends in part on historical causes, such as the invasion of birch from near-by seed sources where pinewood has been felled, and a few instances are known of alteration of the communities in the past. That, however, is not the only reason. Some ecologists have stated that the pine and the birch have closely similar requirements, but a comprehensive study has suggested that there are differences, and which prevails in competition may depend on local differences in climate and soil. The eastern native pinewoods in Deeside and Speyside are almost pure pine, and the birch communities, if any, are peripheral, or on the southerly aspects or on the better soils. Scots pine in Europe and Asia is predominantly a tree of continental climates, and the climate of the eastern Highlands comes nearest to the characteristics of such. The western pinewoods have on the other hand a higher proportion of birch, and some are birchwoods with only scattered pine. With few exceptions the pinewoods are again on the northerly aspects and tend to give way to birch on the better soils. The pine, therefore, tends to compete more successfully in the more continental climates and on the poorer soils.

The flora of the native pinewoods and associated birchwoods is not rich but about two hundred flowering plants and about one hundred mosses, lichens and liverworts were found in the different pinewoods in the recent study, and no claim is made that this is a complete record. The most common species are *Calluna*, *Erica* spp., and *Vaccinium* spp. The field layer can be differentiated into a considerable number of communities, the controlling factors being whether the tree dominants are pine or birch, the degree of closure of the canopy of the dominants, particularly when it is pine, and lastly the soil conditions, and in particular the water status. Most of these woodlands contain undrained bogs and these have their own distinctive plant communities. The rarer plants of the native pinewoods are of considerable ecological interest, but as they are not germane to my subject I shall not say much about them. *Linnaea borealis* L. is not common, and in this respect the Scottish pinewoods differ from those of Scandinavia where this species sometimes forms a carpet in them. There are some unexpected plants in special habitats, such as lime-loving plants where there are pockets of base rich soils in contrast to the typical acid soils of the pinewood. Some plants, typical of a mountain and not a woodland habitat came down into the fringes of the pinewoods, particularly in the western woods where alpines generally come down to lower altitudes.

The age structure of the pinewoods is of interest and importance. They are uneven-aged, but there is by no means a complete gradation of age classes. There is a predominance of old trees of about 140 years and over and trees under 100 years are relatively uncommon. There are often considerable areas of trees of about the same age with occasional much older trees scattered throughout which were the seed source in the past for the natural regeneration. Only exceptionally is there an intimate mixture of any considerable range of age classes. The oldest living trees found were about 300 years old, but a few recently felled stumps indicated that the physical age of Scots pine in the native pinewoods is older.

The average height attained by the pine is only about 50 feet, which is not large. It must be remembered, however, that the site conditions in these woods are on the average not favourable for good tree growth. There are trees up to 70 feet high on the better sites, and exceptionally still taller trees. The average girth is between five and six feet, and occasionally there are trees more than twice that size.

Today the pinewoods have only open and irregular stocking; there are only small

areas and only in certain forests, where the stocking is complete. This poses serious problems, because, apart from the reduced productivity, the consequential rank growth of the field layer communities is one reason for the poverty of natural regeneration.

The poor representation of trees under 100 years old has been mentioned already. In other words there has been little natural regeneration during that period. The reason is partly biotic, namely more intensive grazing during the last century first by sheep and sometimes goats, and later by red deer. Many of the pinewoods are in deer forests where from the last quarter of last century the stock of deer was increased for sporting purposes. That, however, is not the only reason. Even when grazing animals have been excluded, both in the past and more recently, natural regeneration has been disappointing. The causes are complex and not yet fully elucidated. While the old trees produce less seed than younger trees would, the germination potential is good. Scots pine is very sensitive to competition, not only from tree dominants but also from the field layer communities. As already mentioned, the rank growth of certain of these resulting from the open stocking of the woodlands is one of the principal reasons why there is little current regeneration, and this is also related to adverse surface humus and soil conditions.

The health of the Scots pine in the native woods is remarkably good, particularly considering the age of the trees. All the potential insect pests and fungal pathogens of pine are present, but with very few exceptions the populations are at low levels. One would expect root and stem rots to be serious in old trees. It is true that *Trametes pini* (Thore) Fr., which is rarely found on the younger plantations of pine in Scotland, is present and does a little damage, but it is not serious and there is relatively little heartrot due to *Fomes annosus* (Fr.) Cke. Except for local damage by the Pine Shoot beetles, *Myelophilus piniperda* L. and *M. minor* Hartig, insect pests are not important.

The Morphological Variations in the Pine

It is not only of interest but also of practical value to the forester to study the variations which are found in populations of trees, because some of the variants are better than others for commercial forestry. A comprehensive study has been made of the morphological variations to be found in the native pinewoods in respect of habit type, bark types, variations in shoots, buds, leaves—externally and internally, cone types, male inflorescences, etc. This study included quantitative estimates of the distribution of the different variants in the different groups of pinewood. The only other part of the natural habitat of Scots pine where similarly intensive studies have been made so far is in Sweden and it has been found that the pattern of variation of some of these characteristics in Scotland is similar to that in Sweden.

I have only time to deal with the variation in habit type which is of direct practical importance in forestry. By habit type is meant such characteristics of the crown of a tree as angle of branching, length and thickness of branches, arrangement of the foliage, and also such stem characteristics as influence the crown, for example, the tendency for the stem to persist to the apex of the crown or the reverse. The habit types of Scots pine, and in particular the broad and narrow crown types, have been studied for a long period in a number of continental countries and various varieties and forms have been named. The different types are often found growing side by side, hence the variations are not the result of the factors of the site, but habit is influenced by competition and to some extent by rate of growth. There has been a lively controversy, particularly in Sweden and Germany, as to how far these latter considerations control habit type and to what degree genetical characteristics determine it. The Scottish native pinewoods enabled this subject to be studied. The effect of competition is important, but the most distinctive types are probably genetically different.

The most clearly defined habit types in the Scottish woods are:

v. *horizontalis* Don, with horizontal branches retained in well stocked woods. The type has a narrow crown, but there is a similar type with a broader crown.
f. *ascensa* Carlisle, ascending branches maintained in isolated trees. This type has a narrow crown.
v. *pyramidalis* Elwes & Henry, with ascending branches and wide pyramidal crown. The type has a broad crown.
f. *fastigiata* Carriere, with fastigiate branches but with a definite main stem.
f. *condensata* Fries, with fastigiate branches and a composite stem.
v. *pendula* Caspary, with pendulous branches.

Owing to the influence of competition, only a comparatively few trees in any woodland can be assigned with confidence to any particular genotypic habit type, but v. *horizontalis* and f. *ascensa* are frequent to abundant in all the larger native pinewoods. The other habit types are less common.

The Significance of the Native Pinewoods for Current Forestry Practice

The native pinewoods of Scotland are of interest and value from a number of points of view. They are not the least important historical monuments of Scotland and they bear the scars inflicted on them during the past history of this country as do other historical monuments. They are living monuments, however, and if appropriate steps are taken they need never disappear. They are one of the most interesting survivals of our native vegetation, and there is general recognition in all civilised countries that such survivals should be maintained on an adequate scale. Their practical value, however, is not appreciated by all professional foresters. They are relict communities often growing under conditions marginal for tree growth; accordingly the growth of the trees is not impressive, and, as in addition the trees are old, the current increment is low. Moreover, because of their past treatment, or rather maltreatment, the stocking is poor. What then is their significance for current forestry practice?

First, and most important, they are the source of the distinctive native strains of Scots pine. It is of interest that, when the native pinewoods were first appreciated some three and a half centuries ago as a valuable source of timber for naval and other purposes, their importance as a seed source was realised at the same time. In 1621, James VI and I, who was interested in forestry, wrote to the then Earl of Mar to ask for supplies of Scots pine seed from Mar Forest in Deeside. Not long afterwards a steady trade began in pine seed and the plants of Scots pine used to form plantations in the eighteenth century in southern Scotland and England were raised from seed collected in the native pinewoods. During last century, however, strains from the Continent were imported, and many of our present pine plantations are of uncertain origin. Only a perfervid nationalist, however, would claim that everything Scottish is necessarily the best. Have the Scottish strains any special qualities? In the first place these strains have persisted and remained healthy often under adverse conditions of climate and soil. Secondly, it has been mentioned already that there are still in the woodlands a wide range of morphological variants including the habit types already described very briefly; some of these are of value to the silviculturist today, some are not. This pattern of variation suggests that the destructive exploitation in the past has not eliminated the better variants, not only morphological but also physiological. The habit type that is most desirable from the silvicultural point of view is var. *horizontalis*, particularly the narrow-crowned, light-branched form. The evidence suggests that it is not the fastest-growing type, but it is to be preferred, and inherently faster-growing

individuals within the type may be found by progeny testing. F. *ascensa* is faster-growing but less desirable silviculturally. The crossing of these two strains may lead, however, to progeny which may have the desirable qualities of their parents. The other habit types mentioned are undesirable silviculturally, although some may have some horticultural value. It is possible that in the future it may be found that they have desirable qualities, at present undetected. The presence of a mixture of variants, some desirable and others undesirable, makes it necessary, in the absence of controlled pollination, to use scion material and not seed for breeding work. Although the trees are old and shoot growth is accordingly slow, the pine provide satisfactory scion material. As the result of the investigations made, the Forestry Commission is already building up stocks of grafted material of the native strains for breeding work and the formation of tree orchards. Thirdly, there are sites in the high-rainfall regions of the west for which a pine species is desirable, but Scots pine of uncertain origin often does badly under these conditions. The native pine, however, has persisted from generation to generation under these climatic conditions and these western woods should provide a strain which will be successful, and there is some evidence to support this view.

To turn to another aspect of the usefulness of the native pinewoods, they provide opportunities for the study of the potentialities as well as the limitations of Scots pine under adverse soil and climatic conditions. It is important for the forester to add to his knowledge of this for all species, because in this country he is being asked to form his woodlands on poorer sites because of the difficulty of getting land for forestry in competition with agriculture.

The native pinewoods also provide facilities for investigating the influence of pine and birch crops on the soil under relatively long-term conditions. This is a subject of current forestry interest, and some use of these woodlands for this purpose has been made already.

Finally there is the question of the regeneration of these woodlands. I have already mentioned that there is a serious deficiency of the younger age classes and little current natural regeneration. In order to ensure that the range of variants are perpetuated with certainty, it is desirable that their regeneration should be natural. The work done to date, however, has shown that this is very difficult and uncertain and much further research will be necessary to find the answer to this problem. If planting has to be done to ensure the perpetuation of these woodlands then it is essential that the plants be raised from seed collected in the forest in question and covering a range of the variants.

My principal object in addressing you on this subject and in writing a book on the Native Pinewoods of Scotland is to stimulate interest in them, not only amongst their owners, public and private, but in the public as a whole and particularly those with interests in the countryside. They are part of our national heritage and they should be protected and perpetuated for scientific, aesthetic and practical reasons.

CHOICE AND VALUATION IN INDUSTRIAL RESEARCH[1]

by

DR. R. M. LODGE

ON the specific request of the Recorder of the Economics Section, this paper has to be a personal testament. I am the Research Manager of British Nylon Spinners Limited: this is a company making nylon yarns, not nylon fabrics, from nylon polymer bought from Imperial Chemical Industries Limited; it has three manufacturing plants, one in Australia and two in England, and is considering building a fourth. There are 4,691 workpeople, and a staff which numbers 2,130. The Company has a capital of £18,000,000. The Research Department, for which I am executively responsible, has about eighty university science graduates of all sorts of different disciplines such as organic chemistry, physical chemistry, analytical chemistry, classical physics, electronics, statistics and chemical engineering. This Research Department is housed in a large Experimental Plant of 60,000 square feet, and in 30,000 square feet of laboratories, which are in the process of being expanded to 45,000 square feet. The Research Department is responsible for all aspects of yarn manufacture; specifically it is *not* responsible for the development of new uses for yarns, nor is it responsible for research into existing uses for yarns; for this there is a separate Textile Research and Development Department, staffed with textile technologists as well as with chemists and physicists. There is also a Research Group in the Engineering Department. Even having said this, I have not fully described the research effort of the Company because quite a large amount of research is carried on in the plants themselves by technical plant staff.

The reasons for this are twofold. Firstly, the nature of the yarn manufacturing process is such that research work and, in particular, development work can only conveniently be done in the Experimental Plant up to a certain scale; scale in this case means scale of numbers of full-size producing units, rather than scale of size; in other words, the Experimental Plant can work up yarn-producing processes to a one or two producing unit scale, after which recourse has to be made to the plant in order to develop the operation of the process on many more units up to forty or sixty. Furthermore, current processes need to be investigated while they are running on the production line, and it is right that the staff of the Production Department should do this with their own people. Secondly, just as it is necessary to keep production going, so we consider it equally necessary to keep production developing; and we feel that it is more appropriate if the people who are concerned with production itself are not given the added task, on the side-lines as it were, of keeping production developing. If this is done, then the development of production is itself regarded as a side-line and fails through lack of application. We have, therefore, in the Production Department itself technical people who, incidentally, are functionally responsible through their Technical Superintendent to the Research Department, whose specific job it is to keep production developing.

This, then, is the framework within which I write; but I am going to consider only the research work within the Research Department itself. There can be many different classifications of research, and I am going to consider four different broad classes of research which can be enumerated as follows:

[1] Lecture delivered to Section F (Economics) on September 1, 1958, at the Glasgow Meeting of the British Association.

There is that sort of research which can have the objective of giving us better product quality; this clearly comes under the heading of Product Improvement. There is another form of research which seeks to improve the productivity of production processes, and which seeks also to introduce innovation either in the product itself or in the way in which the product is made. Thirdly, the raw material from which the product is made must come under scrutiny, either from the point of view of improving its quality or from the point of view of finding new raw materials with which we may diversify production. Lastly, there is a whole broad field, which one might call Exploratory Research, which can be regarded as the provision of a capital fund of new ideas.

I now want to study just these four main types of research and see whether there are any general factors governing the way in which we at B.N.S. might choose to deploy effort on them. Firstly, product improvement. In a competitive world, and indeed even in a monopolistic situation, quality of product always has some importance. There are, of course, some industries—or perhaps, more accurately, some producers within particular industries—where quality bears a minor role. It is certainly not always a company's policy to sell the highest quality possible. No doubt the majority of people do not want, as private individuals, to buy everything of the highest quality. Perhaps what an individual buyer is seeking more often than anything else is value for money. However, I shall endeavour to explain why, in the case of British Nylon Spinners, which is selling yarns not to private individuals but to a whole industry—the textile industry—generally quality is of enormous importance. In the case of a yarn-user (B.N.S.'s customer), quality means regularity of properties (both chemical and physical) along the length of yarn on a bobbin, and also regularity of properties between different bobbins of yarn. Consider just one form of irregularity, that of a broken filament in a multifilament yarn, i.e. a yarn composed of an assembly of several filaments. Each broken filament represents a potential hazard, because any yarn guide is potentially able to rub the broken filament back up the yarn until a small ball of fluff is formed which is held on to the yarn. This fluff ball, or 'slub' as it is called, is subsequently able to interrupt some textile operation such as, for example, knitting. If, for example, stockings are being knitted from a yarn containing a certain number of slubs, it is reasonably certain that, when each slub appears at the knitting machine, a catastrophe (which is called a 'press-off' in the trade) can happen, so that the partially made stocking falls completely off the knitting needles and cannot be reinstated. The loss to the knitter is a twofold one: first of all, some yarn has been knitted and turned into a useless article and is, therefore, wasted; secondly, one whole cycle of the knitting machine has been wasted as well—a stocking has not been knitted. The former does not matter; there is not more than about sixpennyworth of yarn in a lady's stocking. The latter matters immensely: the stocking knitting machine is a very expensive piece of equipment, difficult to maintain, and slow working; loss of time on this machine therefore represents a considerable loss to the knitter. It is, in fact, literally true to say that B.N.S. can do more to reduce the manufacturing cost of a stocking by improving yarn quality, i.e. improving regularity of properties, than it can by giving the yarn to the knitter for nothing. This, of course, only applies to those articles made by processes which are expensive to operate, and which have in their cost make-up only a small element due to the cost of the yarn itself. The picture is, of course, quite different in the case of ropes, where most of the cost of the rope is the cost of the yarn itself, and the actual costs of rope manufacture are low in relation to yarn cost. Stocking knitters, therefore, are and always will be disposed to buy the best quality yarn possible more or less irrespective of price, because this gives them the desirable trouble-free operation in their mills. As a side issue it might be mentioned that we are looking here for faults in yarn which are comparatively rare events. We are thinking in terms, in

other words, of two or three broken filaments per million yards of yarn; that is, two or three broken filaments between Land's End and John-o'-Groat's: and, at the same time, our Pontypool factory alone is making no less than a quarter of a million miles of yarn per hour. The technical problems of being able to assess these rare events, of being able to sample the yarn and to test it even, are very big indeed. So much for product improvement, which we see in our case, as perhaps in every other, boils down to value for money in the end.

Now let us turn to consider research aimed at productivity and process improvement, and process and product innovation. Looking round, I think it is apparent that, for established industries with traditional products, research of this character has relatively little attraction. It is, on the contrary, of great importance in new industries, and in those old industries where the branch of science or technology on which they are based has become a 'growth subject'. Nylon is an example of the former, electronics of the latter. A company will sometimes decide to put a large amount of effort into research of this sort if it sees its competitors doing likewise, and, in that case, it is usually because it is operating in a field where the appropriate science or technology is growing quickly. In our own case we are a relatively new industry; furthermore, our manufacturing equipment is highly expensive; as a result, productivity is of great importance to us too. This may automatically involve us in a certain amount of process innovation. Moreover, the textile industry itself is highly competitive, and we are selling our nylon yarn in competition with many other sorts of yarn, and therefore product innovation to us is also not without importance. That this is so, can easily be seen by considering for a moment the so-called 'bulked' yarns. The idea originated because it seemed, on the face of it, to be an uneconomic process to spin or extrude a perfectly good continuous filament yarn, to take this yarn and chop it up into the form of staple, and then to pack this staple in bales in a random manner, so that eventually the cotton, woollen and worsted machinery of Lancashire and Yorkshire might find employment in parallelising these random fibres and reducing the parallel arrays down with twist so that a 'spun' yarn results. It was recognised that such a spun yarn, because of its hairy nature, was an entirely different proposition from continuous filament yarn, where there are no protruding hairs, and where the yarn generally is much more smooth because the individual filaments are more nearly parallel. The problem then resolved itself to discovering ways and means of making a continuous filament yarn with the handle and properties of a staple spun yarn. This has been achieved now in many different ways, some of them originating from the research effort of British Nylon Spinners. One way has been to take continuous filament yarn and, by analogy with running a copper wire over one's fingernail, when the wire curls up, run a nylon yarn over a sharp edge and thus causing it to take the form of a very, very small spiral; this traps air, and the configuration is permanent. Consequently, the fabric made from such a yarn has a great deal of the trapped-air characteristics of a spun staple fabric. The impact of this yarn in certain textile fields has been very large indeed. Thus, bulked yarns generally have taken a large part of the market for men's half hose, with a consequent fall in the usage of wool, or, indeed, of any staple for this particular end use.

Thirdly, diversification. A one-product business is more susceptible to the slings and arrows of economic fortune than is a multi-product business. However, unless the current lines are selling badly or are seen to have a shortish life, or, indeed, unless one sees one's competitors likely to go ahead with some profitable line which one might have made oneself, there is comparatively little urge to diversify. However, particular industries today seem to suffer fits of depression at specific times. The textile industry is no exception. There are two ways of diversifying open to a fibre producer, and one is more complicated than the other. The more complicated one is to diversify by making something which will be bought entirely outside the

textile industry. The other is to make an entirely different form of fibre in the expectation that when the sales of one line are in the doldrums, sales of the other are buoyant. The man-made-fibre industry is no exception to these general precepts, and man-made fibres conduct a fairly tough war amongst themselves, so that already there is quite a long list of man-made fibres which have been produced and whose production has now been discontinued. Even the natural fibres have felt the consequences of this constant struggle between fibres; silk now is a rare and most expensive fibre, and this is because of the high labour content associated with its production. It is prudent for B.N.S. to seek new fibre-forming materials, therefore.

Lastly, exploratory research. It is common experience with any sizeable research organisation that, as research proceeds, it is necessary to know more and more about one's product, one's process, and indeed one's raw material as well, in order that all types of applied research may go forward at a satisfactory rate. In order to build a fund of capital of ideas which is accessible for prosecution of profitable researches, it is necessary to carry out exploratory research. The technique for doing this is no different than for any other form of research, except that the objectives are less well defined; it is here that the universities, as well as industry, have a part to play.

Now these four types of research, discussed in some detail above, are by no means exhaustive of the list. But, considering just these, it is apparent that one has many, indeed too many, problems. I am not now going to discuss the question of how the number of men available to carry on the research has to be arrived at; there will always, of course, be too few because the grass is always greener over the other side of the hedge. And it is, of course, right that there are too few people to carry out all the researches one would *like* to carry out. For while, in general, research is a paying proposition (otherwise industrial research would not be carried out at all), at the same time research is an extremely wasteful operation in one sense: many, many experiments and projects fail. Apart from a useful amount of negative information which derives from such failures, the effort is largely wasted. Nevertheless, most companies have to do a certain amount of research, and clearly the minimum is that which is required to enable a company to stay in the business. There is, equally obviously, a top limit to the amount of research which a company can afford to do, and I believe that this top limit is governed by the rate at which the company is prepared to spend capital; for it is clearly useless to have research results of such a nature that they can be applied, and then to find that there is no capital available to turn those research results into production and put the improvements to work.

We have now reached the point in my argument where it has been decided in what general fields one wants to do research. There is, of course, a need to reassess these fields from time to time as both the needs of the company and the state of knowledge change, and also to see if there are any new fields in which research is not being done at the moment; but, having decided the fields, we now arrive at the more subjective and ticklish part in the process of choosing. We have to choose the relative efforts between the fields and between the numerous individual projects which will have arisen within each field. Choosing the relative efforts to be allocated to each of the fields is important, because each field tends to demand different disciplines; for example, in our own case, search for new fibre-forming materials demands the use of organic chemists; in the main, organic chemists are not suitable for working on process improvements because they have not the appropriate scientific and technological disciplines at their fingertips. I have no universally applicable formula for how to do this, but I do find that once the die is cast, it is useful not to change effort ratios between fields.

And now for the individual problems themselves; at this point there must be

many criteria for exercise of choice. One important criterion is the desirability of achieving the expected result of the research. It is my own experience that this can sometimes be tested quite simply by asking the appropriate people what they will do with the results of the research. It is surprising how often the answer boils down to something after the fashion, 'Well, it would be interesting to know these results'; 'interest' is very low down in the scale of desirability. There are, of course, several forms of desirability: financial, technical, and commercial are the obvious ones. Very frequently these different forms of desirability work in complete opposition one to the other; what may be financially desirable is technically to be appalled; what may be technically desirable is commercially unacceptable. As usual, compromise has to be reached even before any research has started at all, and this is why it is important that the research and development side of the business keeps in close contact with the financial and commercial sides.

A second criterion of choice must be success at a reasonable price. (This is the thesis of 'value for money' again.) We have to consider the chances of success of any given research project. It is useless to have a burning desire for what, in the present state of knowledge, is impossible. You may have noticed that people use interesting phrases to indicate impossibility, but that these phrases have to change with the times: 'jumping over the moon', for example, is not so impossible now as it was fifteen years ago. It is, perhaps, the assessment of the likelihood of success which is the largest unknown in all worthwhile investigations, and it is for this very reason that it pays to assess the likelihood of success at regular intervals. If this is done as the research proceeds, one begins to find a trend in these assessments. With some researches the likelihood of success increases as the research goes on; with others it stays constant; and there is yet a third type where success appears to recede. Clearly, when the law of diminishing returns is operating, the research must be stopped; when the likelihood of success stays constant, it is often wise to reinforce the project with more men and to see what happens then; if it still stays constant, perhaps it is best to discontinue research on that particular project too.

A third criterion of success is the time factor. A relevant question here is, 'Why do it now?' Will the results, in other words, be needed when they become available? A second question is, 'Will the results *still* be needed when they become available?' Research results which become available too late are clearly wasteful. It is not, however, so obvious that research results which become available too soon may also be wasteful: they can be wasteful, if they are premature, from two points of view: firstly, other work of more pressing importance might have been done; secondly, if the results had been obtained later, the state of knowledge might have been such that they could have been obtained either quicker or the results themselves might have been better.

The fourth criterion is that of the ability of the company as a whole to cash in and develop the research results. Will raw material be available, or, as I have mentioned before, will sufficient capital be available in order to develop the process? This does not exhaust, of course, the list of criteria, but I think it is enough for my purpose. It is, of course, difficult enough to arrive at a satisfactory conclusion having considered these criteria in the case of each individual suggested research topic. What, however, is much more difficult is to compare research topics which have gained acceptance and are on the active list when they have themselves got onto the active list for very different reasons. One project, for example, may offer a very high return of capital, but the chances of success are low. Another may offer very small returns, but be technically most desirable. Consequently, like is competing with unlike for the research man-year. It is this task of comparing like with unlike which is so very difficult and so very subjective. The only rule which can be offered is that on no account must long-term researches be pushed out by short-term trouble-shooting. Trouble-shooting may not anyway be the responsibility of

the Research Department and, if prosecuted to the exclusion of long-term research, soon renders the overall effort of any Research Department abortive.

This paper is necessarily incomplete. It is virtually impossible to analyse all the processes which are gone through in order to pick on what one hopes are the right research topics to work on. As I said at the beginning, this is my personal testament, and I have deliberately not overstrained economic arguments. This is in the hope that the discussion will teach me a very great deal.

ANTIDOTES TO APATHY[1]

by

DR. F. W. CRAWFORD

A COMMON criticism of today's university students is that their corporate life lacks vitalism. Those who remember the nineteen-thirties look for the drive and sense of urgency that gripped the student body of pre-war days. If we look at their societies now, no strong currents are visible. Generally, there is little interest in politics, though national figures can be relied upon to draw the crowds and create a passing surge. Religious societies are strong in many colleges, yet dormant in others—often in near neighbours—while cultural and academic groups wax and wane with the passing of a few enthusiasts. Occasionally a major moral or political issue such as Suez or the use of atomic weapons, evokes the student voice, but, more often, its opinions go unexpressed. If the pearls are not to be trampled underfoot in a mere scramble for degrees and diplomas, the planning of university expansion must encourage and cater for effective participation in corporate activity. The fact that many students within the present framework take no such part demands a search for reasons and for antidotes.

The Depression, at home, and the European issues of the Spanish Civil War, Fascism and Nazism could be focused more readily than the diffuse issues of global politics today, and if students are not united in their voice and looking forward, perhaps it is because the causes to unite against are not as easily discernible as they were twenty years ago. As the Hungarian uprising proved, when an issue is clear, today's student is as ready to speak and act as his predecessors ever were. Accepting the existence of this potential, a background is required against which it is natural for it to act and to develop.

To the extent that a university is only an imperfect reflection of the world outside, an opportunity missed or a false step taken is not irrevocable, but certain worthwhile opportunities come only once and are not easily paralleled afterwards. For those who take only a passive part in corporate life there is the exchange of experience and the broadening of outlook and cultural interests which comes from mixing and conversing with others of similar age and development. For those who take a more active part through membership of clubs and societies these benefits are enhanced, while others who assume the organising roles in these clubs and societies, or the Union, or take part in formal debates, have the chance to test their impact and ability within a critical circle but without the wider implications of such an experiment outside. The possession of intelligence does not necessarily bring with it the ability of a great organiser, or speaker, or leader, and in a world of ever-increasing complexity, requiring more and more highly qualified people for relatively humdrum jobs, there is no necessity or desire to construct their university background so that all students are stimulated to take part in corporate life on the most active level. What is desirable is that those outside the stream shall be encouraged to enter it, even if not to change its course.

In considering the reasons for non-participation, a broad distinction may be made between those which are personal to the student, and those which are the results of external influences. In the first category, unawareness of what the university has to offer in extra-curricular activity is a prime factor, and is often contributed to by shyness or late development. Freshers' conferences and pre-sessional meetings

[1] Lecture delivered to Section L (Education) as part of a session on 'The Student Day' on September 1, 1958, at the Glasgow Meeting of the British Association.

organised by local education authorities can be a great help, but may easily defeat their own objects by providing a surfeit which only tends to confuse. An earlier attack on the problem within the sixth forms is probably more valuable.

Having reached the university, the student may find that he does not possess the capacity to do the academic work required of him, and take an effective part in corporate life. This is an unsatisfactory aspect of the entrance system in some university departments where more students are accepted than can be catered for in subsequent years. There is some strength in the supporting argument that this avoids a rigid line being drawn at entrance and provides an opportunity to sort out unsuitable students on the basis of a year's work, but surely a refinement in selection technique is required rather than wasteful expenditure of public money and a demoralising atmosphere for many whose first year is to be their last. An entrance standard should be set sufficiently high for those who reach it to find the subsequent course well within their capabilities though, equally, admission should not be regarded as ensuring a degree or diploma without further effort.

Further personal reasons for non-participation may stem from the fear of doing badly, or desire to do particularly well in examinations; these may both lead to a disproportionate emphasis on academic work, and will be aggravated if right techniques for effective study have not been acquired. In these cases the value of a close staff–student relationship is apparent, and a tutor who can advise on the right balance between work and other activities from personal knowledge of the student is necessary.

Turning now to external influences, the siting of a university can be expected to exert a profound effect. Those in large centres of population, drawing a substantial proportion of their students from the area, experience the problem of the home student. His pre-university environment, with all its interests and associations, weakens the university's potential influence and, particularly if much of his time is spent in travelling to and fro, the home student can easily come to regard the university as a 9-to-5 workshop. Ironically, those amongst them who could benefit most from its influence will be the least likely to feel it. The remedy is clearly to encourage intending students to apply only to places where it will be necessary for them to live away from home. Even then, the disadvantages mentioned may still apply to some extent if they have to live in lodgings. The attractions of a new city, particularly strong if it happens to be London, will compete with college activity for their interest. Travelling time may still be substantial if accommodation is scarce near to the university, and this, at its worst, may turn into a 'home from home'.

A union building and halls of residence, placed near to the main university buildings, provide the necessary facilities for corporate activity to develop, and avoid the difficulties experienced by home students and those living in lodgings, but which should represent the focus of interest seems to depend on the size of the university's student population. In the smaller British universities, the union is usually all-important, but generally there is a shift in emphasis towards the hostels as numbers increase. This allows a higher proportion to enter into things without being swamped.

Many students who would wish to enter more actively into affairs are prevented by the nature of their courses. This is particularly true of medical students after their pre-clinical years, and of engineers, whose overloaded courses demand attendance at lectures in the morning and at laboratories most afternoons. Neither lengthening of the courses, nor reduction of the subject-matter contained in them are attractive propositions at the moment, but if these classes of students are to have the opportunities given to those in, say, the arts faculty, such changes are necessary.

Within their departments, some students experience pressure to apply themselves

only to academic work, and occasionally a professorial embargo is placed on the taking of union or society offices. There is much to be said on both sides of this question, and it is understandable that the academic staff of a university should wish to see their students obtaining the best academic results possible within their capabilities, but this does not necessarily represent the most profitable way of employing their energies. The man who has to sacrifice his social life to obtain an upper second would probably be better off with a lower class and a broader background to his education.

So far, no mention has been made of money and the effects it has on a student's likelihood or ability to enter into his university's corporate life. Too much is certainly likely to isolate its possessor from his fellows and encourage him to indulge in more expensive outside activities than others can afford, but the results of having too little are not quite so obvious since most of the benefits, such as meeting and talking with other students, are free. Of the right sort, and performed in moderation, vacation work can be of value, but the extended periods of unsuitable work that many students have to do to make ends meet not only lack this positive value but eat into the time that should be used on academic work. This increases the load in subsequent terms and decreases the time for extra-curricular activities. It is not suggested that the level of maintenance should be such that a student does not need to do any vacation work, but that he does not have to rely on this to keep him alive in term-time.

From the suggestions made so far, the elements of the student background against which we should expect apathy towards corporate activity to shrink emerge as a closely-knit university, fully residential, with a well-equipped union, and sited away from the distracting influences of large cities. The timetables of its courses would leave ample leisure hours, and a close student–tutor relationship would provide the guidance to avoid abuse or failure to take opportunities. To a greater or lesser degree, many of our universities embody these ideals, but they are only ideals, and in planning the expansion of already-existing establishments it is not necessarily possible to approach all of them. The enormous expense involved in the long-term aim of full residence requires that we look for short-term improvements over the present facilities. The Ashby Plan, and the possibility of extending dining arrangements of existing halls to cater for students in lodgings, are two suggestions that have already received attention.

The strengthening of the staff–student relationship is something that can be accomplished without the expenditure of a substantial sum of money, yet it is a much-neglected factor outside the older universities. If this step alone could be taken, and the feeling inculcated where it does not exist at present, that the action is not of 'going to' but of 'belonging to' a university, then a major advance would have been taken against apathy towards corporate life and the idea that '. . . the true university is a collection of books'.

RESEARCH COMMITTEES, 1958–59

Grants of money, if any, from the Association for expenses connected with researches are indicated in heavy type.

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Seismological investigations.—Dr. R. Stoneley, F.R.S. (*Chairman*), Mr. E. Tillotson (*Secretary*), Mr. E. F. Baxter, Miss E. F. Bellamy, Prof. P. G. H. Boswell, O.B.E., F.R.S., Mr. B. C. Browne, Sir Edward Bullard, F.R.S., Dr. K. F. Chackett, Dr. G. E. R. Deacon, F.R.S., Dr. A. T. J. Dollar, Dr. A. E. M. Geddes, O.B.E., Prof. G. R. Goldsbrough, C.B.E., F.R.S., Dr. M. N. Hill, Mr. J. S. Hughes, Sir Harold Jeffreys, F.R.S., Dr. E. R. Lapwood, Rev. C. Rey, S.J., Dr. G. D. Robinson, Dr. N. A. Routledge, Mr. H. V. Shaw, Sir Frank Smith, G.C.B., G.B.E., F.R.S.

SECTION C.—GEOLOGY

To consider and report on questions affecting the teaching of geology in schools.—Prof. T. N. George (*Chairman*), Mr. A. Bray (*Secretary*), Prof. J. G. C. Anderson, Miss M. A. Arber, Prof. W. G. Fearnsides, F.R.S., Dr. J. F. Kirkaldy, Prof. L. R. Moore, Mr. J. Myers, Prof. Sir William Pugh, O.B.E., F.R.S., Dr. K. S. Sandford, Dr. S. H. Straw, Dr. Dighton Thomas, Dr. Mabel E. Tomlinson, Dr. A. K. Wells, Prof. A. Wood.

To excavate critical geological sections in Great Britain.—Mr. W. H. Wilcockson (*Chairman*), Mr. J. M. Edmonds (*Secretary*), Prof. P. Allen, Sir Edward Bailey, M.C., F.R.S., Mr. W. S. Bisat, F.R.S., Prof. W. G. Fearnsides, F.R.S., Prof. T. N. George, Prof. H. L. Hawkins, F.R.S., Dr. R. G. S. Hudson, Prof. V. C. Illing, F.R.S., Prof. O. T. Jones, F.R.S., Dr. J. F. Kirkaldy, Dr. Murray Macgregor, Mr. T. G. Miller, Prof. L. R. Moore, Dr. F. J. North, O.B.E., Prof. F. W. Shotton, M.B.E., F.R.S., Prof. F. H. Stewart, Dr. W. E. Swinton, Dr. F. S. Wallis, Prof. D. M. S. Watson, F.R.S., Prof. T. S. Westoll, Prof. W. F. Whittard, F.R.S., Prof. Alwyn Williams, Prof. S. W. Wooldridge, C.B.E.

SECTIONS D, K.—ZOOLOGY, BOTANY

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SECTION E.—GEOGRAPHY

To prepare a glossary of geographical terms with agreed definitions in English, including reference to origin and to current use and misuse.—Prof. L. Dudley Stamp, C.B.E. (*Chairman*), Mr. G. R. Crone (*Secretary*), Prof. H. C. Darby, Prof. W. G. East, Mr. E. O. Giffard, M.B.E., Mr. A. F. Martin, Prof. A. A. Miller, Dr. C. J. Robertson, Mr. C. T. Smith, Dr. G. T. Warwick, M.B.E., Prof. S. W. Wooldridge, C.B.E., Mr. R. A. Skelton.

SECTION H.—ANTHROPOLOGY

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Committee to investigate by experiment the denudation and burial of archaeological structures. Dr. G. W. Dimbleby (*Chairman*), Dr. P. A. Jewell (*Secretary*), Prof. R. J. C. Atkinson, Dr. I. W. Cornwall.

FLUORINE AND DENTAL DECAY: FIFTY YEARS OF RESEARCH[1]

by

JOHN CAMPBELL, PH.D., F.D.S., D.D.O., L.D.S.

Lecturer in Preventive Dentistry, University of Glasgow; Consultant in Charge of the Temporo-Mandibular Department, Glasgow Dental Hospital

IT HAS been known for over a hundred years that fluorine is a normal constituent of human teeth. The element was mentioned occasionally in the dental literature of the last century, as for example when Erhardt described in 1874 how he added fluoride to the diet of dogs and the effect upon their teeth. Then there was the famous physician, Sir James Crichton-Browne, who suggested as far back as 1892 that fluoride might be added to the food of children as a means of warding off dental decay.

However, systematic research did not really begin until 1908, when McKay of Colorado Springs reported endemic staining of the dental enamel, occurring in certain districts of the Rocky Mountains. Seventy to 100 per cent of the children reared in those parts had teeth ranging in colour from brown to opaque white.

McKay's report reached Dr. G. V. Black, the acknowledged Grand Old Man of dentistry of his day. Black visited the endemic area, confirmed the discovery, and published a classic description in a widely read text-book.

It was difficult to determine what caused the mottling; it might have been a deficiency or an excess; it might have been something from the soil or something from the water. McKay wrote: 'There are present in waters certain other varieties that exist only in traces, the determination of which requires much more elaborate techniques, spectroscopic and polariscopic, which are beyond the capacity of ordinary chemical laboratories.'

In 1908, neither Black nor McKay had the slightest idea that fluorine was the element they sought. It was not until 1931 that fluorine was isolated as the responsible agent. But the water was suspect, and in the first two decades of the century communities began to change their water-supplies hoping to eradicate the dental disfigurement.

One small mining town named Bauxite could be quoted as an example. This town had evolved from a pioneer community, served by shallow wells. With the coming of industry, the increase in population, and as a safeguard against typhoid, artesian wells were sunk. It was noticed that the children born thereafter had badly stained teeth. Wise counsel prevailed; the deep wells were sealed, water was brought from a distance, whereupon mottling ceased.

Bauxite, therefore, offers an early example of a city changing a water-supply, otherwise satisfactory, for the sole reason of an endemic dental effect.

Soon after 1931, when it was realised that fluorine was responsible, the research workers returned to Bauxite and tested the water in the sealed wells and found that it contained fourteen parts per million of fluoride, which is fourteen times greater than desirable.

After Black's death in 1915, McKay continued the investigation. He examined the teeth of children in adjoining states as well as in his own, including children of differing ethnic stock, the Indians of southern Arizona. During this period, he collected data of 7,000 individuals in twenty-six communities.

[1] Paper read to Section B (Chemistry) on September 2, 1958, at the Glasgow Meeting of the British Association.

Now, for a long time, shepherds and farmers in various parts of the world, notably North Africa, had recognised a peculiar staining in the teeth of their animals. Investigators, apparently unaware of the work of Black and McKay, made a noteworthy addition to the epidemiology of the condition. They were able to reproduce experimentally similar staining in the teeth of white rats, sheep and dogs, initially by using water from an endemic district. The final proof came when they caused mottling with distilled water to which fluoride had been added.

Now, up to this point, the sole interest was to find the cause of mottling and to eradicate it. However, the observers became increasingly aware that mild mottling was associated with reduced dental decay; indeed, this association had been indi-

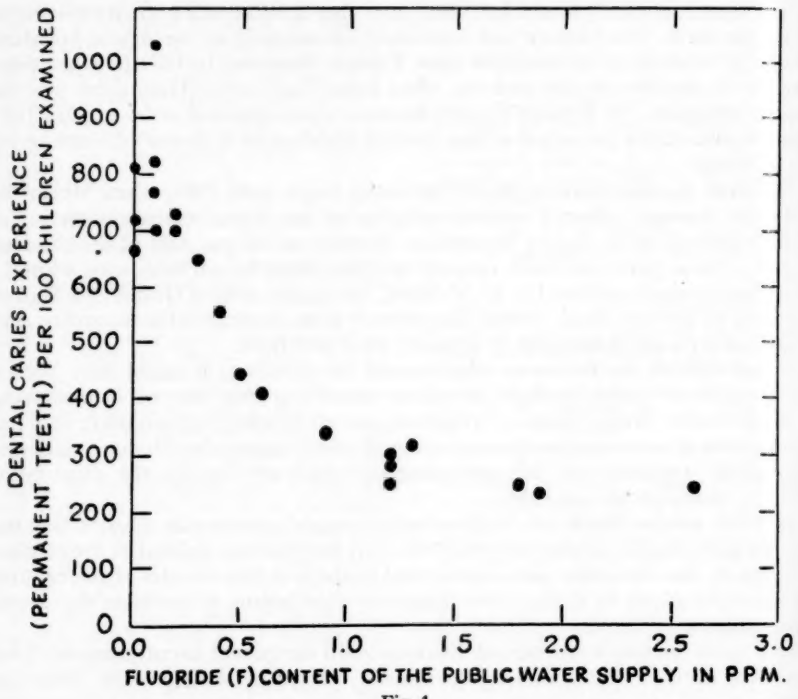

Fig. 1

(From Dean, H. T., Arnold, F. A., Jr., and Elvove, E.: *Public Health Report*, Aug. 7, 1942.)

cated in an article published as far back as 1907. Black himself commented on it, but ascribed it to the fresh air and sunlight enjoyed at those altitudes.

When they began to realise that mild fluorosis was linked with a low susceptibility to dental caries, the research workers set out to determine quantitatively the fluoride in the waters of various cities; they wished to see how the concentration in parts per million related to the caries experience. This was the pattern of research in the late 1930s. Trendley Dean, one of the pioneers, investigated twenty-one cities and demonstrated the inverse relationship between the parts per million and the caries rate. (Fig. 1.) This was true up to a concentration of about 1·5 p.p.m., but the caries prevalence did not drop much when the concentration rose above this figure.

The next step followed logically: it was to determine the concentration which would give the maximum protection with the minimum disfigurement. (Fig. 2.) The

figure shows that the caries rate was low when the fluoride was 1 p.p.m.; it also shows that mottling was negligible at this level.

Incidentally, it should be known that mottling is not always caused by excessive fluoride intake: a non-fluoride type of mottling is fairly common in regions such as the city of Glasgow where the fluoride concentration is 0·07 p.p.m. Sometimes it takes the form of an opaque white patch and sometimes the enamel is heavily impregnated with an orange stain.

The mottling which is characteristic of excessive fluoride is not invariably ugly; in its mildest form it can only be perceived by magnifying glass, and it may take the shape of tiny white specks which actually enhance the beauty of the teeth.

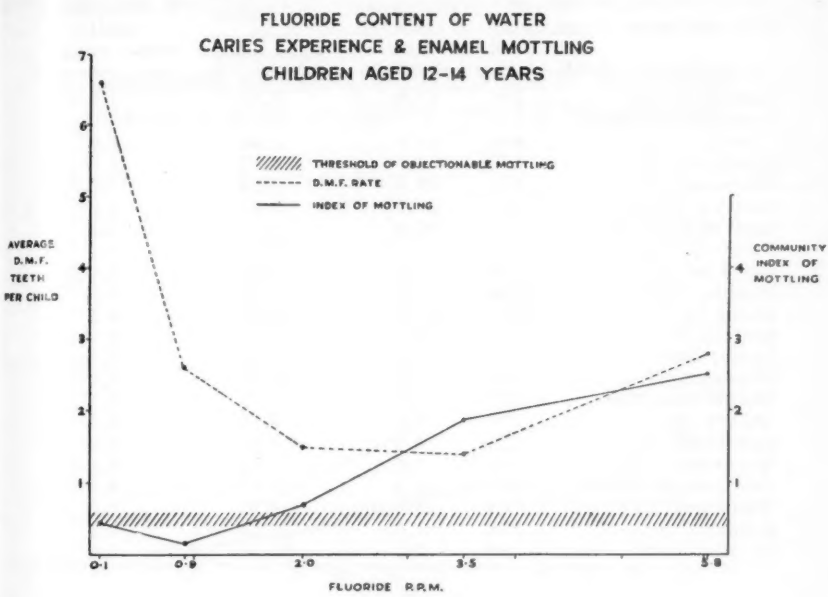

Fig. 2

(From Forrest, Jean R., 'Caries incidence and enamel defects in areas with different levels of fluoride in the drinking water,' *British Dental Journal*, vol. 100, No. 8, 195–200, April 17, 1956.)

Fig. 3 represents a table compiled by Russell and Elvove. It will be seen that carious cavities were numerous in towns with low fluoride; in a town with 0·1 part of fluoride per million water, the average child had 10·37 decayed, missing or filled teeth. But, at the other end of the table, where the water contained 1·2 p.p.m. the D.M.F. index dropped to three or less. This table typifies many made in other parts of the globe.

Now, it is not pleasant to report that the average child had three carious cavities in a town optimally fluoridated. Nevertheless, if ten cavities per child can be reduced to three, then some beneficial factor has undoubtedly been at work.

But, can we say with certainty that the benefit was actually derived from the fluoride in the water? Could it be calcium, for example? The reply is that when calcium in parts per million is correlated with the caries experience, the graph is meaningless and shapeless.

An interesting survey was carried out in eight suburbs of Chicago in the late 1930s. Children from these towns were selected by random sampling. When their teeth were inspected a significant discovery was made; an area of low caries prevalence was found in the midst of high prevalence. This was in the town of

Aurora. When the various water-supplies were analysed, every town had low fluoride except Aurora, which had 1·2 parts per million.

The research worker came, therefore, to regard the graph depicting Aurora's caries experience, as a sort of 'yard-stick' which could be given to any town contemplating fluoridation. That is to say, it became a curve of prediction; it showed what could be expected. From the date of installing the plant, there should be a steady decrease in decay. As more and more children are born and bred under the fluoridation regime, the statistical curve will merge with the curve of

City and State	No. of children examined	Per cent of children caries free	No. DMF per child with caries experience	F. conc. (ppm) public water supply
Galesburg, Ill	273	27.8	2.36	1.9
Colorado Springs, Colo.	404	28.5	2.46	2.6
Elmhurst, Ill	170	25.3	2.52	1.8
Maywood, Ill	171	29.8	2.58	1.2
Aurora, Ill	633	23.5	2.81	1.2
East Moline, Ill	152	20.4	3.03	1.2
Joliet, Ill	447	18.3	3.23	1.3
Kewanee, Ill	123	17.9	3.43	0.9
Pueblo, Colo	614	10.6	4.12	0.6
Elgin, Ill.	403	11.4	4.44	0.5
Marion, Ohio	263	5.7	5.56	0.4
Lima, Ohio	454	2.2	6.52	0.3
Evanston, Ill	256	3.9	6.73	0.0
Middletown, Ohio	370	1.9	7.03	0.2
Quincy, Ill.	330	2.4	7.06	0.1
Oak Park, Ill	329	4.3	7.22	0.0
Zanesville, Ohio.	459	2.6	7.33	0.2
Portsmouth, Ohio	469	1.3	7.72	0.1
Waukegan, Ill.	423	3.1	8.10	0.0
Elkhart, Ind.	278	1.4	8.23	0.1
Michigan City, Ind	236	0.0	10.37	0.1

Fig. 3

(From 'Fluoridation in the prevention of dental caries,' American Dental Association, Jan. 1953.)

Aurora, the naturally fluoridated town. This in fact was the experience of every town fluoridated so far. (Fig. 4.)

Now, America was not the only country interested. In 1928, Ainsworth found endemic enamel staining in Maldon in Essex. In the small town of West Mersea nearby, the fluoride ran as high as 5·8 p.p.m. Endemic mottling has been reported from twenty-nine countries.

An episode in Britain is worth recording. When Tyneside children were evacuated to Cumberland during the bombing, their new school dentists were quick to notice that the children from South Shields had better teeth than their fellows from North Shields. The difference was so marked that they reported it to the Minister of Education, who sent Dr. Weaver to investigate. Weaver found that decay in twelve-year-old children was 45 per cent less in South Shields. The water north of the river contained 0·25 p.p.m. fluoride, and that south of the river 1·25 p.p.m.

Incidentally, a point of interest emerges here; an unusual caries prevalence is more likely to be recognised by a stranger than by the dentist in the area engaged all day contending with decay. Wherever he practises, a dentist tends to accept the caries prevalence of his neighbourhood as typical of the country as a whole; he has to practise elsewhere for a while to appreciate whatever difference exists.

This explains why a dentist in a high fluoride area may not realise the good fortune of his young patients: he may not realise that each child averages 50 per cent less decay than its counterpart in another county.

Other excellent field studies have been conducted in Britain, notably by Miss Forrest and her co-workers. They found a delay of about ten years in a high fluoride area. For example, a child reared in a low fluoride region might have eight carious cavities at the age of ten, but if he had lived in a high fluoride area, then he would be aged twenty before he had eight cavities.

Miss Forrest found that adults had reduced caries susceptibility when the fluoride was about 1 p.p.m. This applied to all age-groups; for instance, between twenty-one and twenty-five, there was 38 per cent less decay than in low fluoride districts. In

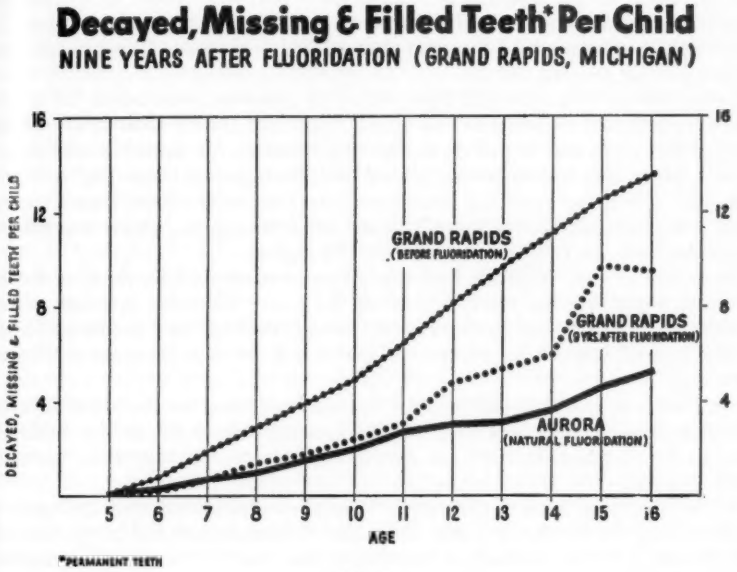

Fig. 4

(From 'Fluoridation of water,' Hearings before the Committee on Interstate and Foreign Commerce, House of Representatives. H.R. 2341.)

adults over forty, there was 17 per cent less. She adds: 'The difference in the clinical conditions of mothers of the same age in the two groups was more striking than the D.M.F. count would suggest.' I quote her again: 'In addition, among mothers in the low-fluorine group caries was more severe and of the teeth which were present and decayed twelve times as many showed apical infection.'

An outstanding research was prosecuted in the Scottish town of Fort William, and described in H.M. Stationery Office publication, *Industrial Fluorosis*. It should be clear from the start that this was not primarily a dental study. The inquiry was set up to safeguard the health of the workers in the aluminium factory. Cryolite is used as a flux in the smelting process, and since it contains fluoride, the suspicion arose that the workers might be inhaling dangerous quantities from the atmosphere of the workrooms. The Government wished to be assured that the incidence of spinal arthritis was not unduly high, because cases of ankylosis have been reported from certain districts of India and China where the water contains as much as 14 p.p.m.

The fluorine ion has a selective affinity for calcium and calcified matter, which explains why it is found in the bones and teeth rather than in the soft tissues.

There was another reason for the Fort William investigation. Local farmers had been complaining that their cattle were being poisoned by the fumes emitting from the factory chimneys. The crofts to the north-east were chiefly affected because the prevailing wind blows up the valley from the south-west.

The complaints were justified; analysis showed that at one point, grass sited a quarter of a mile from the chimney actually contained 1,000 p.p.m. fluoride dry weight. It should be noted that the fluoride was on the grass, not in it. Fortunately, the concentration dropped rapidly as the distance from the source increased.

Subsequent to the publication of the report, smoke-consumers were installed in the chimneys and extractor-fans in the work-rooms. These measures put an end to the nuisance. It was assuring to read in the report that 'there is apparently no excess incidence of pains and aches in the back in the most exposed workers', and again, 'The routine medical histories showed little evidence of an unusual rate of sickness, past or present'.

The Secretary of State at that time, Mr. Tom Johnson, instructed that the teeth of the school children should be examined. His Chief Dental Officer, Dr. Douglas, inspected the teeth and found no disfiguring staining. He found in addition, that the caries prevalence was in general accord with the high rate obtaining in Scotland, which was only to be expected considering the similarity of the fluoride concentration in the domestic water. Fort William had 0·07 p.p.m., which was not unlike the concentration in Glasgow, which is 0·071 p.p.m.

The public of Fort William had never been endangered by fluorine toxicosis. The water supplying the town drains off the peaty hill-sides into the reservoir, which is tantamount to saying that it does not soak through rock possibly containing fluoride. Indeed, the low p.p.m. proved that it had not even been contaminated by the smoke.

At one stage it was thought that the vegetables grown for human consumption in the district might have absorbed harmful quantities from the smoke, but analysis proved to the contrary. In 1945, the date of the inquiry, few vegetables were grown in Fort William.

We turn the clock back to the early 1940s when discussions were going on as to the advisability of fortifying water deficient in fluoride, for the protection of the teeth. By 1942, a vast amount of knowledge had been gathered. The correlation between the caries index and the amount of fluoride in the water had been intensively studied. However, putting the hypothesis into practice was not a step to be taken lightly. It was not enough to argue that generations had blissfully been drinking water highly fluoridated by Nature with every evidence of good health. The advocate of 'man-made fluoridation' had to examine every aspect of his project to ensure that nothing had been overlooked. For example, there had to be a safety margin to allow for inordinate drinking habits, heat and humidity. The repercussions range widely and involve agriculture, veterinary science, and industry.

It should be borne in mind that several industries, brewing principally, depend on bacterial fermentation. Before we could introduce fluoridation we had to be certain that it would not harm brewing, baking, or sewage treatment, to mention only a few of the processes utilising biological principles. As far as baking and brewing are concerned, these processes have been successfully operated for ages in regions where the fluoride concentration is higher than the proposed 1 part in a million. In addition, experiments in vitro showed that fermentation is not inhibited at 1 p.p.m.

But, in final analysis, the verdict on the safety and efficacy of fluoridation devolves on one single factor. If this could be settled satisfactorily, then the project could 'be given the green light' so to speak. Taking it for granted that naturally fluori-

dated water has been consumed for hundreds of years, it only remains to determine the difference in biological action between water fluoridated by the chemist and that fluoridated by Nature. If there is no difference, then we can proceed with confidence, knowing that the experience of generations will be repeated. Let us examine this point.

Fluorine is one of the most widespread elements. It occurs in various types of rocks, in the soil, in the sea and in everything that grows therein. During the ancient history of the world, the polar ice-caps have melted and the plains of Europe and America have been flooded, which explains how fluoride got into so many articles of diet, and how it gets into the human body. Every human being has fluorine in his bones and teeth. The theory has been advanced that it is a trace element, but the experimental procedure is so difficult that this point has not been established.

By way of further explanation, let us imagine that a shower of clean rain has just fallen on a hill-side. It soaks into the rock, which for the purpose of our analogy contains fluoride. Fluoride in rock is not easy to dissolve and the water usually has less than 2 p.p.m., unless assisted by dilute sulphuric acid derived from pyrites in overlying rock, when it may rise to 14 p.p.m. This so-called 'naturally fluoridated water' is nothing more than pure water with an added salt to provide the fluoride ion. According to this reasoning, artificially fluoridated water and naturally fluoridated are identical.

It has been argued by persons opposed to fluoridation that it is not the fluoride ion that is biologically active. In contradistinction, the world's leading chemists declare that in low concentrations such as 1 p.p.m. the fluoride ion, not the salt, is the active agent in the human body. The Report of the United Kingdom Mission states, 'The physiological effects of the different fluoride salts will depend on the absorbability from the intestinal tract'. Then again, 'In drinking water when the concentration applied is of the order of 1 p.p.m. the effects of the difference in solubility of different fluorine compounds tend to disappear, and the readiness with which they yield fluoride ions is the chief factor in governing their use as fluoridating agents for the prevention of dental caries'.

During the period of preliminary discussion, the water-engineer had to give assurance that the concentration could be actively maintained. He stated that the addition of fluoride to water presented no new problem: the mechanics of feeding fluoride into a pipe-line were no more involved than those of other chemicals in daily use. The water-engineer stated that he could meter the element into the water-supply to an accuracy of plus or minus 10 per cent. At first glance, this might appear an over-generous tolerance, but it refers to 10 per cent of 1·0 p.p.m. That is, if we intend to hold the concentration at 1·0 p.p.m., then it will not rise above 1·1 p.p.m. nor drop below 0·9 p.p.m.

Subsequent experience has shown the water-engineer that if the water enters the pipe-line at 1 p.p.m. then it is virtually the same at the end of a twenty-mile pipeline; there is no fluoride encrustation problem.

The water-engineer had to assure us further that the fluoridation plant could not be easily sabotaged by a maniac or an enemy agent aiming to poison the population. I apologise for introducing this extravagant fancy, but much has been made of it in the literature of the opponents of fluoridation; the phrase 'turning on the tap' has been used. If the city of Glasgow is taken as an example, and bearing in mind the gallons used per head of population, 1,000 tons of sodium silicofluoride—the chemical likely to be used—would have fed into the water every day to maintain the concentration at minimal lethal dosage.

It is within the bounds of possibility that an accident might incapacitate the plant, but in that case the machinery would stop. Even if it went berserk, nothing more than the contents of the loading hopper would run into the water. The Chief

Medical Officer in Anglesey states that if this happened in the apparatus under his control, the concentration would only rise to 2 p.p.m. which is far short of the lethal concentration of 400 parts per million.

In the fluoridation schemes in current use, the concentration is measured every day by colorimetric comparison, and in addition, specimens of the water are sent to the central authority for its own analysis.

This might be the time to interpolate that there are communities throughout the world where the domestic water contains far too much fluoride. For example, a small town called Bartlett in Texas had 8 p.p.m. until steps were taken to reduce it. The citizens enjoyed good health although their teeth were mottled. This part of the programme should not be forgotten; it is just as important to reduce fluoride excess as to augment fluoride-deficient water.

Our discussion has reached the point in the history of fluoridation when the preliminary studies were complete. The planning was over; the children had been medically and dentally examined; the charts had been made and the base-lines drawn. The hypothesis was about to be tested.

January 1945 was the historic date when the first controlled fluoridation project was set in being. This was in a town of 175,000 inhabitants near Lake Michigan; its name was Grand Rapids. In May of the same year, Newburgh on the Hudson River began fluoridation. The third was the Canadian town of Brantford in Ontario, which started in June, 1945.

In each study, plans had been laid beforehand. Each fluoridated town had its control which was left fluoride-free. Grand Rapids was originally controlled against Muskegon, but after six years the citizens of Muskegon asked that the control should be abandoned; they requested that their town should be fluoridated. Newburgh was suitably controlled against the neighbouring town of Kingston, which remains fluoride-free to this day. Brantford had no control until after three years had passed, but this omission was rectified and Sarnia and Stratford now act as controls. It happened that Stratford had a natural concentration of 1·3 p.p.m., whereas Sarnia was fluoride-free: this gave Brantford a 'two-way' control. However, the first three years were not wasted because Brantford had its own pre-fluoridation figures for assessing the extent of the improvement.

The children in each of the paired towns were examined medically and dentally at intervals, and these checks have continued during these thirteen years. The Newburgh–Kingston investigation included a medical inspection of the eyes, ears, skin, blood and urine. Radiology was used to determine the density of the bone and its maturation. The frequency of limb fractures was compared with those of fluoride-free towns.

Methods for assessing dental caries were standardised in each study. The teeth were inspected clinically and radiologically. The films were sent to a radiologist in another city for diagnosis of carious attack. Prior to despatch, the films were coded and intermingled so as to rule out bias.

These researches were mostly conducted in children for the simple reason that they were available, and needless to say, to fulfil the requirements of the investigation, the children had to be born in the district and in continuous residence. Children born elsewhere might not have the fluoride ion built into the dental enamel.

Miss Forrest found during her study of the teeth of English mothers that the effect of fluoridation was carried into adult life. Nevertheless, although the improvement usually amounts to 60 per cent in childhood, it decreases as the individual grows older. Fluoridated teeth are stronger but they are not immune to dental caries. It should be borne in mind that one decayed tooth left untended will affect others like the proverbial rotten apple in the barrel. As mentioned, fluoridation postpones decay by about ten years, which provides a valuable amount of leeway, enabling the dentist to preserve the mouth as a whole.

The cost of fluoridation is small and might be met by the saving in dentists' bills. In the United States the capital cost of the plant and the operative charges work out about 9–14 cents per head of population per annum.

The vital statistics of the naturally fluoridated and artificially fluoridated towns have been compared with the fluoride-free towns; no significant difference has been found. (Fig. 5.) Persons antagonistic to fluoridation have alleged that mortality rates from cancer, nephritis and heart disease rose in Grand Rapids since fluoridation began in 1945. The figures quoted are incorrect and no such rise has occurred. Indeed, mortality rates are improving in Grand Rapids.

The three pilot schemes in Grand Rapids, Newburgh and Brantford, were intended to run for ten years and actually have run for thirteen. It was reckoned that a minimum of ten years must pass to make the test valid. In the ten years from birth onwards, a child ought to calcify and erupt twenty deciduous and twenty

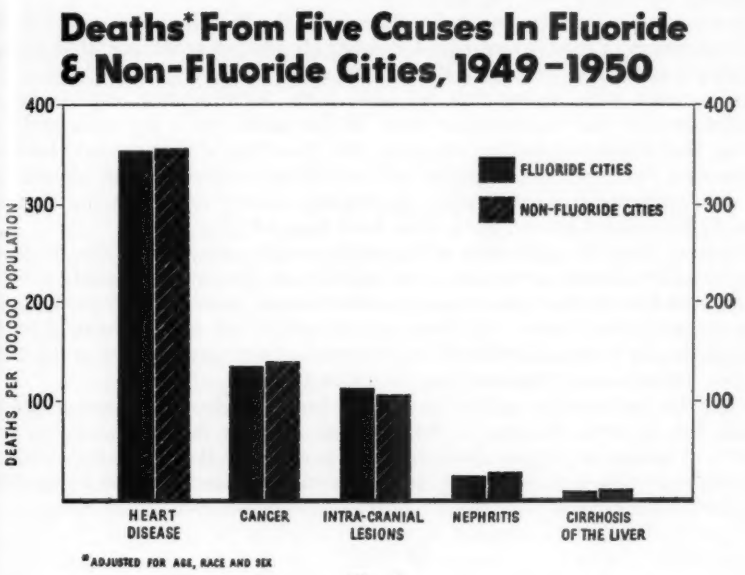

Fig. 5

(From H.R. 2341, as Fig. 4.)

permanent teeth, and some of them will be exposed to the hazard of decay for several years.

Brantford has issued its final report, but Grand Rapids and Newburgh are continuing to gather data; these two towns have issued ten-year reports. In each study, it was found that the dental decay dropped 60 per cent, and the procedure is declared safe and beneficial.

Great Britain has not been inactive. In 1952, a mission was sent to the United States to study fluoridation. The excellent report issued in 1953 endorsed fluoridation. It was suggested that four study centres should be set up in Britain and, after much negotiation, Kilmarnock, Anglesey, Watford and Andover were selected. Fluoridation has been going on in these towns for two years.

In July 1958, fluoridation ceased in Andover due to the agitation of a pressure-group. It should be clearly understood that it did not cease because of anything discovered to its discredit.

The first phase of the research is over. The doctors, dentists, water-engineers

and the chemists have more or less completed their assignments: they discovered the beneficial results of fluoridation at 1 p.p.m. and have proved it harmless. However, although all our hopes have been fulfilled, in a sense we are not completely satisfied; we do not yet know the *modus operandi*. The remaining research must pass more and more into the hands of specialists. The bacteriologists will probably study the effect of fluoride on bacterial metabolism. As mentioned, fluoridation does not interfere with fermentation, but, nevertheless, there are special features in its action on the surface of the teeth. It may be that due to the affinity of fluorine for teeth, a high concentration on the surface may restrict bacterial activity at this level. Physicists and biochemists can find use for their talents in the future fluorine researches; they can use x-ray diffraction to study the effect of fluoridation on the lattice structure of the enamel. They will use radioactive tracers to study the entry of minerals into the enamel. Unfortunately, the half-life of fluorine is only 112 minutes.

Let me sum up by referring to Dr. Longwell, the Principal Scientific Officer in the Department of the Government Chemist. He says, in substance, that naturally fluoridated water and controlled fluoridated water are biologically identical. This is synonymous with saying that we have been accumulating experience with fluoridation since the beginning of time. If this statement is not sufficiently convincing, then we should remind ourselves that three fluoridation projects have been in action for thirteen years, together with several others for a slightly shorter time. The data gathered from controlled fluoridation closely resembles the data from naturally fluoridated towns; the graphs have merged. (Fig. 4.)

It may be that the opponents of fluoridation will achieve their aim of denying this great public health measure to the children of Britain for possibly a decade. However, as I see it, fluoridation has gained too much momentum in north America to be stopped there; those who have experienced it will not be deluded by false propaganda. Up to date, 33,400,000 individuals in 1,644 communities in the U.S.A. and 444,000 in Canada are receiving fluoridated water.

I conclude my remarks with a paragraph from the *American Journal of Public Health*. Arnold says: 'As long as the adoption of water fluoridation is left to the vagaries of public or popular decision—and it is one of the few that is subject to such unpredictable action—every bit of scientific evidence should be readily at hand for persuasive use.'

Epilogue

The last paragraph in the Newburgh Report of 1953 says: 'Dentistry has added a new milestone in public health. With the expansion of water fluoridation programs it may be expected that dental caries will lose its dubious honour of being the most prevalent disease to which humanity is subject.'

COLOUR VISION

PROFESSOR R. W. PICKFORD, President of Section J (Psychology), devoted his Address to the Section at the Glasgow Meeting of the British Association (see *Advancement of Science*, **XV,** *No.* 58, p. 104) to a review of some problems of colour vision and colour blindness. Sections I (Physiology and Biochemistry) and J (Psychology) devoted the afternoon of the same day to a joint discussion of certain research papers on colour vision. Dr. W. A. H. Rushton, F.R.S., reader in Physiology in the University of Cambridge, considered the chemical basis of human colour vision. Commander Dean Farnsworth, of the United States Office of Naval Research, contributed a paper, entitled 'A trial framework for the study of colour discrimination'. Dr. D. H. Fender, of the Department of Physics at Reading University, dealt with the effect of eye-movements on colour vision. Mr. R. Lakowski, of the Applied Psychology Unit at the University of Edinburgh, presented a paper on 'Age and colour vision', the full text of which is published below.

AGE AND COLOUR VISION

By R. Lakowski

The aim of the present research was to find out what effect (if any) age had upon the ability to discriminate colours. There was no special search for those who had any colour defects, and subjects who were 'normal' were just as welcome as those who were not. This project in its very nature is a vertical study. The youngest subjects tested were 5 years of age, the oldest 90. To help in the evaluation of the results a certain order has been imposed upon the data. The results collected have been placed into eight age-groups, each covering ten years, except for the two youngest groups, which each have a span of five years. In all, over 500 subjects were tested (a random sample of approx. 250 males and 250 females).

All subjects who are included in the present analysis were tested on the Pickford anomaloscope in the following equations: red-green, yellow-blue, and violet-blue/green; the 11th edition of Ishihara Plates, the Dvorine Colour Perception Test, and, for the detection of defects in blue, blue-green and violet, additional five plates were used (Farnsworth F.2, F.3, F.5; Willmer W.2, W.11) (1).

The R-G equation will be considered first. Results are tabulated into a two-fold classification for clarity's sake: Class 1—the 'normal' or best subjects, whose matching range and mid-point on the anomaloscope falls within the $\pm$S.D. for normal population; Class 2—the 'anomalous', including all the six sub-classifications like the Protanopes and the Deuteranopes, the Extremely Protanomalous and the Extremely Deuteranomalous, and also those who are called Protanomalous and Deuteranomalous (2). Subjects with minor defects (deviants and colour weak) are excluded.

Only data on the Pickford anomaloscope and the two sets of pseudo-isochromatic plates are given (Fig. 1). Results on the Nagel anomaloscope are not included because too few subjects were tested (160 in all) to merit classification according to age. However, it is sufficient to mention that in the classification of R-G anomalous on both anomaloscopes a high degree of correlation was obtained ($r = 0{\cdot}94$, in fact) (3).

The histograms are self-explanatory, but a few comments may be offered. Discrimination in the R-G equation is not uniform throughout the age-groups. There is a general build-up of the number of subjects with good R-G colour

discrimination till we reach the peak at the fourth group, that is between the ages of 26–35. Then, there follows a slight decline in the number of such subjects until in the last two age-groups very few are left; in fact, barely ten per cent could be included in this class. Statistically speaking, any difference of approximately 15 per cent in the incidence of good subjects between one age-group and any other is significant at the 0·05 level. That is, such percentage differences could occur by chance only once in twenty times. (Differences of 20 per cent are significant at the 0·01 level.)

It will be seen that there is a remarkable resemblance between the shapes of the three histograms. However, there are noticeable differences between the total number of subjects passed by the two sets of plates, Ishihara passing more subjects with no mistakes than does Dvorine. These differences are easily explained. The Ishihara has been designed to detect only R-G anomalies. On the other hand the Dvorine, in addition to testing R-G vision, will also pick out some subjects who confuse the yellows, the blues, and the blue-greens. Therefore, the Ishihara will pass more subjects without mistakes than does the Dvorine, especially in the older age-groups.

Data for subjects with best R–G discrimination

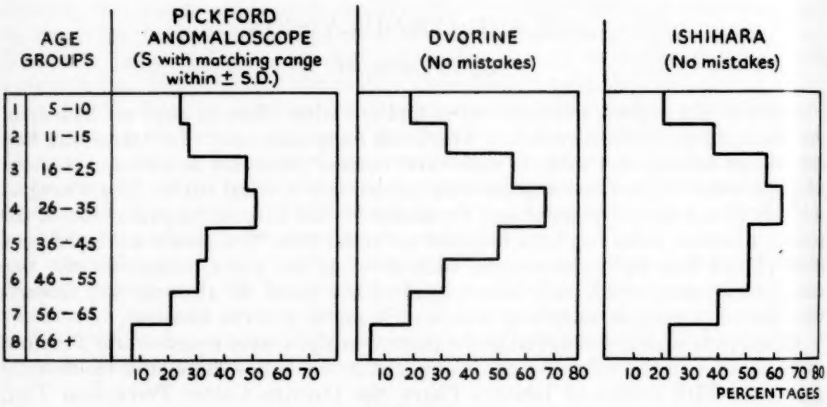

Fig. 1

Class 2, *the* '*anomalous*'.—The essential fact that emerges from the present research is that there are more major defectives than has been hitherto stated. This does not mean that the data are inconsistent with the percentages that are quoted in other findings on the incidence of the extreme anomalous. In the present research the percentage of Protanopes and Deuteranopes is almost 2 (9 out of 500 subjects), thus confirming what has been well known so far. Where there is a discrepancy, however, is in the incidence of the 'less extreme anomalous' subjects.

The three histograms for the distribution of R-G anomalous subjects (Fig. 2) indicate two areas of higher incidence of such defectives: the youngest group of subjects and the two last age-groups. These findings should not be surprising even in the light of previous investigations, if the following facts are taken into consideration. First, all the extensive researches on the incidence of R-G anomaly were done on subjects between the ages of 18 and 40, and therefore are valid only for those age-groups, not giving any indication of what happens outside these limits. Second, to make large-scale testing possible, subjects are first screened on pseudo-isochromatic plates and only those with many mistakes are retested by more elaborate means. On such data frequencies of the incidence of R-G anomaly

are computed. There is, however, evidence to show that many 'simple' R-G anomalous subjects can read such tests making very few mistakes and therefore miss the more rigorous testing on the anomaloscopes.

Now let us consider the data available from the analysis of the other two equations, namely, yellow-blue and violet-blue/green. Defects in these equations are usually described as being due to some kind of defective receptor-systems and, being congenitally determined, are, therefore, supposedly very rare. But it has also been suggested that excessive macular pigmentation of the foveal area could produce responses similar to those that are given by subjects with the congenital defect of tritanomaly. Thus, persons could mix up yellow-blue and/or violet-blue/greens from two different causes—defective receptor system or heavy pigmentation of the macula (4). The results in this research indicate that a great many people, especially after 30 years of age, become less efficient in their discrimination of these four colours. The numbers are far in excess of anything that could be expected from congenitally determined anomaly. Therefore, at least one other

Data for the R–G Anomalous Subjects

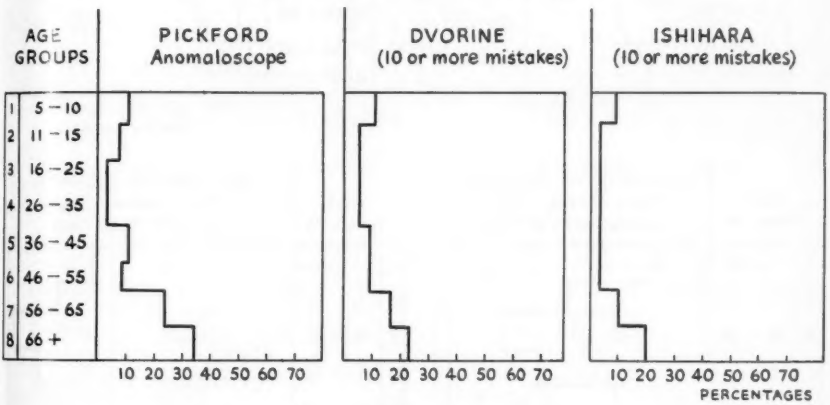

Fig. 2

factor must be involved in the causation of these results, and this factor could be the progressive thickening of the macular pigment.

As the statistically determined classification of defective colour vision is independent on any theoretical consideration of causes of poor discrimination, I will retain the term 'anomalous' for subjects who do not fall within the normal distribution. Thus, I shall talk about yellow-blue and violet-blue/green anomalous.

We shall now consider (Fig. 3) the results obtained on Pickford yellow-blue and violet-blue/green equations, Farnsworth No. 5 Plate for the detection of tritanomalous vision, and Willmer W.2 Chart for the demonstration of congenital central tritanopia. Data for the other plates are excluded, because of lack of consistent results (see (1)).

Interesting facts emerge. There are fewer subjects who could be classified as perfect, and in addition the best groups are now found among the younger people. For the yellow-blue test on the anomaloscope it is the 16–25 age-group that has the highest incidence of those with best discrimination. For the violet-blue/green test it is the second-youngest age-group that is best. Though such is the trend of the incidences, one word of caution has to be given. Because of the relatively small number tested in each group (50), it is worth remembering that, statistically

discrimination till we reach the peak at the fourth group, that is between the ages of 26–35. Then, there follows a slight decline in the number of such subjects until in the last two age-groups very few are left; in fact, barely ten per cent could be included in this class. Statistically speaking, any difference of approximately 15 per cent in the incidence of good subjects between one age-group and any other is significant at the 0·05 level. That is, such percentage differences could occur by chance only once in twenty times. (Differences of 20 per cent are significant at the 0·01 level.)

It will be seen that there is a remarkable resemblance between the shapes of the three histograms. However, there are noticeable differences between the total number of subjects passed by the two sets of plates, Ishihara passing more subjects with no mistakes than does Dvorine. These differences are easily explained. The Ishihara has been designed to detect only R-G anomalies. On the other hand the Dvorine, in addition to testing R-G vision, will also pick out some subjects who confuse the yellows, the blues, and the blue-greens. Therefore, the Ishihara will pass more subjects without mistakes than does the Dvorine, especially in the older age-groups.

Data for subjects with best R–G discrimination

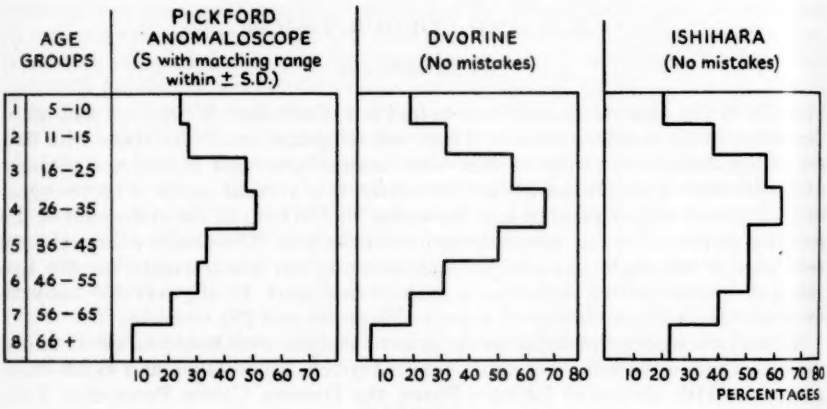

Fig. 1

Class 2, *the* '*anomalous*'.—The essential fact that emerges from the present research is that there are more major defectives than has been hitherto stated. This does not mean that the data are inconsistent with the percentages that are quoted in other findings on the incidence of the extreme anomalous. In the present research the percentage of Protanopes and Deuteranopes is almost 2 (9 out of 500 subjects), thus confirming what has been well known so far. Where there is a discrepancy, however, is in the incidence of the 'less extreme anomalous' subjects.

The three histograms for the distribution of R-G anomalous subjects (Fig. 2) indicate two areas of higher incidence of such defectives: the youngest group of subjects and the two last age-groups. These findings should not be surprising even in the light of previous investigations, if the following facts are taken into consideration. First, all the extensive researches on the incidence of R-G anomaly were done on subjects between the ages of 18 and 40, and therefore are valid only for those age-groups, not giving any indication of what happens outside these limits. Second, to make large-scale testing possible, subjects are first screened on pseudo-isochromatic plates and only those with many mistakes are retested by more elaborate means. On such data frequencies of the incidence of R-G anomaly

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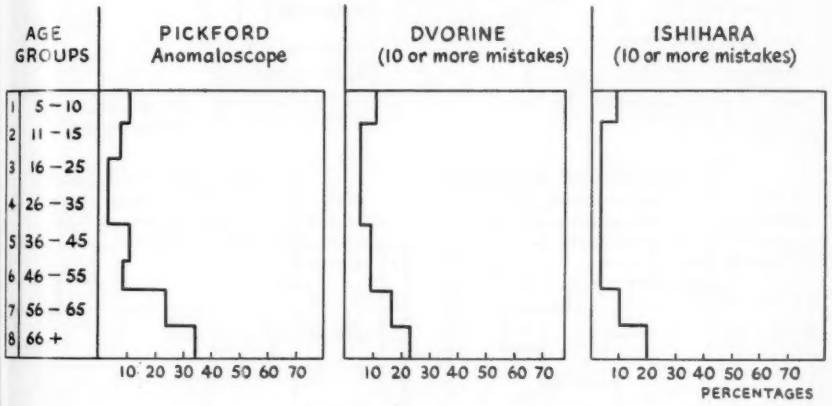

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speaking, only differences of about 15 per cent can be taken as significant. Nevertheless, it is quite safe to assume that the drop in number of perfect subjects after 40 years of age is quite significant. It could not arise from sampling error.

Data for subjects with best yellow-blue and violet-blue/green discrimination

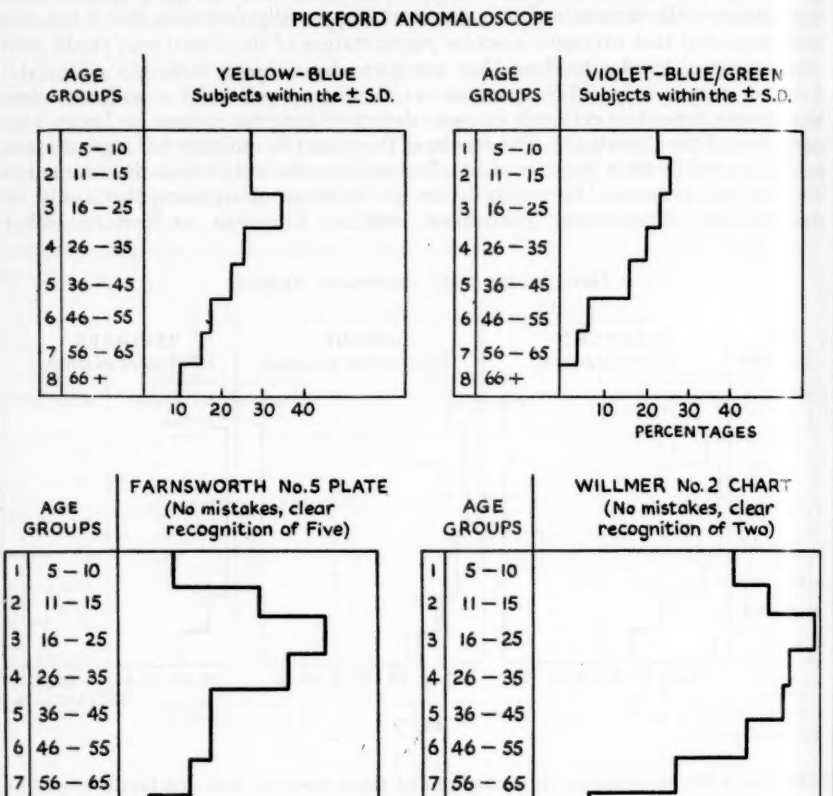

Fig. 3

We will consider now those who could be classified as major defectives in these two equations (Fig. 4).

First, let us look at the histograms depicting the incidence of those who fail on the two plates. The light area on each of the diagrams corresponds to the percentages of those who misread the numbers on the plates, the tinted to those who do not read it at all. There are some interesting differences as to the type of misreading that we find in the various age-groups. The younger people misread it most frequently as the letter S or as two figures, viz. S and 5, or 5 and 3. In a few cases it is read as 8 and 5. In the older age-groups double reading is less frequent and people see it as either an 8 or a 3 or rarely as the letter S. Only two subjects in the total sample read it as the number 2. On the Willmer plate those who misread it most frequently called it 8 or misread it as the number 3. A rare response was to

call it 9, 7, or 5. The shape of the histograms for those who do not read it at all follows the already familiar pattern. There are very few people who fail it in the 16–25 age-group, and the percentages gradually build up till we come to the last age-group where over 70 per cent do not see it at all.

Data for defective subjects in yellow-blue and violet-blue/green vision

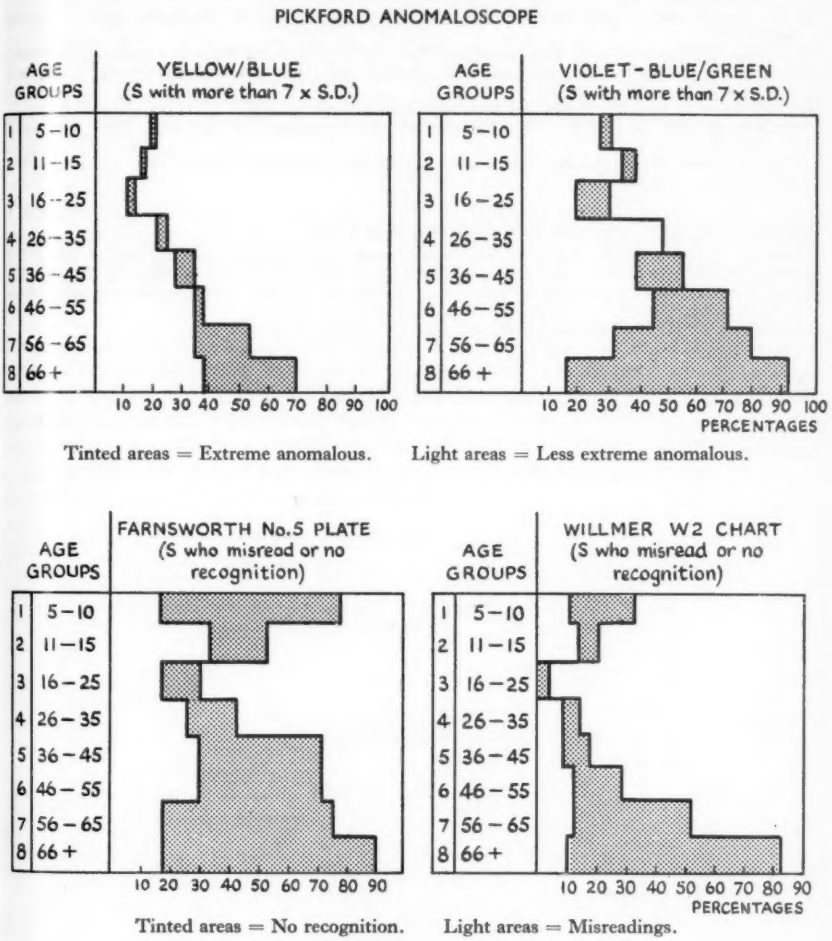

Fig. 4

Results on the anomaloscope.—As in the former diagrams, a distinction is made between those who can be classified as very defective and those who could be only called 'simple' anomalous. The tinted areas again represent those who are completely defective, and the light areas, the other class of subjects. Any finer analysis has, at present, been omitted. From the shape of these histograms we notice that the incidence of persons with poor discrimination increases as age increases, with an almost regular progression, the 16–25 age-group having the smallest incidence of such subjects.

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(3) On correlation of performances (or classification) on various anomaloscopes—excluding Pickford's.
WILLIS, MARION P., & FARNSWORTH, DEAN (1952): 'Comparative evaluation of anomaloscopes', p. 53. Medical Research Lab. Report No. 190. Released by Gerald J. Duffner, Commander, MC, U.S. Navy.

(4) Suggestion of the role of macular pigmentation in colour vision.
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SEISMOLOGICAL INVESTIGATIONS

SIXTY-THIRD ANNUAL REPORT of the COMMITTEE on Seismological Investigations. (Dr. R. STONELEY, F.R.S., *Chairman*, Mr. E. TILLOTSON, *Secretary*, Mr. E. F. BAXTER, Miss E. F. BELLAMY, Prof. P. G. H. BOSWELL, O.B.E., F.R.S., Mr. B. C. BROWNE, Sir E. C. BULLARD, F.R.S., Dr. K. F. CHACKETT, Dr. G. E. R. DEACON, C.B.E., F.R.S., Dr. A. T. J. DOLLAR, Dr. A. E. M. GEDDES, O.B.E., Prof. G. R. GOLDSBROUGH, C.B.E., F.R.S., Dr. M. N. HILL, Mr. J. S. HUGHES, Sir H. JEFFREYS, F.R.S., Dr. E. R. LAPWOOD, Rev. C. REY, S.J., Dr. G. D. ROBINSON, Dr. N. A. ROUTLEDGE, Mr. H. V. SHAW and Sir FRANK E. SMITH, G.C.B., G.B.E., F.R.S.)

PERSONAL

The Committee offers its felicitations to Sir H. Jeffreys on his retirement from his professorial chair, and hopes that he will have long life and good health to be able to do all the things he has planned.

THE GRAY-MILNE FUND

The remaining part of the Crombie Bequest, amounting to £500, is still deposited with the Treasurer of the Association; as mentioned in last year's report, this sum has been promised to the Crombie Seismological Laboratory, Cambridge, for the purchase of scientific equipment, but in view of alterations to the time installation and to the long-period seismographs it was agreed to defer making the actual payment until the items of equipment were needed for immediate use. The sum of £400 remains invested in Defence Bonds.

Receipts

	£	s.	d.
Balance, July 31, 1957	709	8	11
Trust income	80	14	10
Interest from Defence Bonds	10	0	0
	800	3	9

Payments

	£	s.	d.
Secretarial expenses	13	17	10
Balance at bank, June 28, 1958, less outstanding cheque	786	5	11
	800	3	9

INSTRUMENTS

There has been no change in the location of the instruments belonging to the Committee during the past year. The instruments are located as follows:

Milne-Shaw Seismographs

No. 1. Science Museum, South Kensington.
„ 3. Edinburgh.
„ 4. Downe, Kent (in storage).
„ 6. Hermanus, South Africa.
„ 27. Perth, Western Australia.
„ 63. Suva, Fiji.

The Jagger Shock Recorder is at Fort Augustus, Scotland.

THE INTERNATIONAL SEISMOLOGICAL SUMMARY

By the Hon. Director, Dr. R. Stoneley, F.R.S.

In view of the Committee's close association with the I.S.S. from its inception in 1924 up to 1946, when it came under the International Association of Seismology, a note of the present position of the I.S.S. may be of interest.

After over ten years of service, Sir Harold Jeffreys has relinquished his post of Honorary Director, and Dr. R. Stoneley was appointed at the Toronto General Assembly of the U.G.G.I. as his successor. Mr. J. S. Hughes continues as Assistant Director, and thanks to the courtesy of the Director-General of the Meteorological Office the project still receives free accommodation and office facilities at Kew Observatory, and in addition the Superintendent of Kew Observatory continues to provide the clerical help needed in making payments to the Staff.

Throughout its history, the finance of the I.S.S. has been a continual source of anxiety to successive Directors, and this state of affairs shows no sign of abating. At present the main contribution is from U.N.E.S.C.O., through the Federation of Astronomical, Geodetic and Geophysical Services, the committee which administers the 'Permanent Services' of the Unions of Astronomy and of Geodesy and Geophysics. The British Treasury has for some years made an annual grant of £2,000 for the purpose of reducing the long arrears of publication. A subvention has also been made from the funds of the International Association of Seismology and the Physics of the Earth's Interior. Just recently the Government of Canada has made a grant of 1,000 dollars per annum for three years. The progressive reduction of the U.N.E.S.C.O. grant in recent years has militated against an all-out effort to make up the arrears of publication, and the possibility is now being explored of discontinuing the free distribution of the I.S.S. and of charging an economic price. An added difficulty is the increase in the number of stations and the amount of data coming in; though this is scientifically desirable, it adds to the financial burden at a time when costs of production have greatly increased.

By Mr. J. S. Hughes

In addition to myself the staff consists of Mrs. Sanders, who continues to do all the clerical work and organises the preparation of the data received, Mr. Wavish and Mr. Gulley, who share the work of completing the final manuscript of the Summary. In addition to these full-time workers we have help from Mr. Biddle and Mr. Strickland, whose part-time services are valuable in co-operating on various stages. Outside help in copying records is also being given.

Attention must be drawn to the great increase in work to be done on the Summary, particularly from the third quarter of 1950 on which the staff is at present engaged. The great Assam earthquake in August, itself one of the largest on record, was followed by very many aftershocks. These were in many cases as widely recorded as the initial one, but were apparently not always from the same epicentre. The result, of course, is an enormous amount of work, taking up a great deal of time and adding much to the volume of copy to be seen through the press. Counts of epicentres for recent periods of the summary are as shown:

Year	*Epicentres*	
1946	519	
1947	468	
1948	568	
1949	647	
1950, January–June . .	339	
July–August . . .	198	
September . . .	80	approximately

So that at *pro rata* estimate the figure for 1950 should lie between 800 and 850. These do not take into account the great increase in the number of stations recording each earthquake, which is probably in a similar ratio to the increase in the number of earthquakes.

SEISMOLOGY AT KEW OBSERVATORY, 1957–8

By Dr. K. H. Stewart, Superintendent

The records of the Galitzin three-component seismographs and of the short-period vertical component instrument were maintained. Where possible an estimate of the 'magnitude' of earthquake shocks (on the Gutenberg-Richter scale) is now included in the monthly bulletins in addition to the data previously given. During the year the bulletins listed 592 earthquakes, giving provisional epicentral distances for 134 of them and magnitudes for 211 of them. Seismograms were lent to the National Institute of Oceanography for microseismic work and copies of seismograms were supplied, on request, to several overseas observatories.

British Earthquake of February 9, 1958

Assuming a focus at the base of the Upper Layer (Granitic) we, at Kew, determine the following preliminary epicentre:

$$H_0 = 23\text{H}.\ 21\text{M}.\ 06\text{s}.;\ 54°\ 12'\ \text{N}.\ 1°\ 45'\ \text{E}.$$

about 40 miles NE. of the 1931 Great North Sea earthquake.

The departures (O–C) are as follows:

Station	△	*Wave*	*h.*	*m.*	*s.*	O–C *s.*
Kew	3°·8	ePn	23	21	54	+0·2
		iP*		21	57·5	−1·2
		iPg		22	06	+0·2
		e		22	11	
Durham	2°·0	Pn		21	39	−0·5
		Sn		22	04	−0·7
Rathfarnham	4°·8	Pg		22	41·5	−0·3

THE DEPARTMENT OF GEODESY AND GEOPHYSICS, CAMBRIDGE UNIVERSITY

Head of the Department: Mr. B. C. Browne

Crombie Seismological Laboratory—by N. A. Routledge. The timing installation has been modified and is now controlled by a crystal clock. This apparatus has been working continuously since February 1958 with satisfactory results.

In view of the development of defects in the sapphire pivots of the long-period seismographs, the form of suspension is being changed by utilising fine wires. One of the two instruments has already been converted and is working satisfactorily.

Experimental. The results of last year's seismic work in the Atlantic Ocean are still being worked out and discussed. This summer, Sir Edward Bullard and Dr. M. N. Hill are continuing the programme of seismic exploration in the Atlantic from R.R.S. *Discovery II.*

Mr. D. H. Matthews has been making a series of determinations of the velocity of compressional waves in solids under pressure.

Theoretical—by R. Stoneley. The investigations of the velocity of Rayleigh waves across a two-layer ocean floor have been continued, and comparison made with the studies of group velocity made by various observers. The general agreement is satisfactory.

A study of the variation of amplitude with depth, and the distribution of energy, in Love waves in a double surface layer has been completed, and published in the Gutenberg Commemoration Volume *Contributions in Geophysics*.

NATIONAL INSTITUTE OF OCEANOGRAPHY

Director: Dr. G. E. R. Deacon, C.B.E., F.R.S.

H. M. Iyer's investigation of the composition and direction of arrival of microseisms is being continued. Microseisms associated with four well-defined meteorological situations have been studied in great detail, the waves being filtered into discrete period bands of one-second width before analysis on the correlation meter, and the original theory modified to allow for the small correlation usually observed between the Love wave components. The results show clearly that the microseismic source follows the storm, although some distance behind it. The microseismic source appears to have finite size, one reason being the tendency of waves of different periods to produce the necessary wave interference in different places near the storm area.

A detailed study has been made of the decrease of the Rayleigh/Love wave ratio with increasing distance of the generating source.

The following studies have been made in collaboration with Mr. B. J. Hindle:

1. Preparation of refraction diagrams, to correct for the variation in velocity of Rayleigh waves with ocean depth. The reciprocity principle was used, the waves being assumed to originate from the recording station and radiate outwards, getting refracted as they go along. These diagrams are very convenient to use since they make it easier to take account of the position of the generating source in relation to the recording station in applying correction for refraction.

2. Qualitative analysis of the data from Mr. Tucker's electronic horizontal seismograph, which was working for the whole of the autumn and winter, 1957. All the major storms in the Atlantic Ocean during this period have given rise to appreciable microseismic intensity. On twenty occasions the activity has exceeded 10 microns of earth movement.

IMPERFECTIONS OF ELASTICITY IN THE SHELL

By Sir H. Jeffreys, F.R.S.

C. Lomnitz announced at Toronto some experimental results on phase lags in rocks under small periodic stresses, and had found that the lag was nearly independent of the period. This suggests a law of flow under constant stress such that the total flow increases like log t. H. Jeffreys has applied this to the damping of the variation of latitude and to the blunting of seismic waves as they travel, and finds that to account for them simultaneously the law should be replaced by $t^{0.17}$. The modified law gives a satisfactory account of the rotations of the Moon and Mercury, and leads to no contradictions with other data, as elasticoviscosity does. It does not, however, permit cellular convection and does not account for approximate isostasy; the latter however concerns stresses near the elastic limit in any case.

TIMES OF P ABOUT 20°

By Sir H. Jeffreys, F.R.S.

Jeffreys has made a reinvestigation to test regional differences in the times of P up to 30°. Results for European earthquakes were very similar to those found

in a previous paper, and little new information was found for Japan. There are now a fair number of north American earthquakes with enough stations near the same azimuth to give useful travel times. A set from the I.S.S. combined with a special study by Lehmann showed that the times at short distances are definitely closer to the European than the Japanese ones. It is possible that from 18° to 30° the American times are a little shorter than the European ones, but the difference is not firmly established.

Lehmann's observations of a large second arrival Pd about 20° in an Azores earthquake were too late to correspond to the continuation of the Jeffreys-Bullen times up to 18°. They can be reconciled with the new European times up to 17° or so; Pr would have to enter about 17° instead of 19·5°. Two hypotheses have been examined. In one the Pd data are interpreted as due to a cusp in the time curve at 21°. This hypothesis, in its simplest form, was found to lead to curvatures with the wrong sign. In the other they were interpreted as due to a cut-off by a change of velocity. This was acceptable. The depth of the discontinuity would be about 0·03R; there would be little discontinuity of velocity, but a considerable one of velocity gradient against depth.

Pd has not been satisfactorily confirmed in other earthquakes, and Lehmann herself is dubious about its reality. However, it is worth while to see whether the data can be consistently interpreted, even though at the most they seem to represent only a peculiarity of a limited region.

BRITISH EARTHQUAKES

By Ernest Tillotson

Nine earth tremors have been noted since last year's report.

(1) February 9, 1958. A tremor felt most strongly on the NE. coast of East Anglia, but also throughout the coastal regions of East Anglia and Yorkshire. The epicentre has been determined by the observers at Kew Observatory from observations made at Durham, Kew, and Rathfarnham (near Dublin).

(2) March 9–13, 1958. Four minor tremors. Felt at Glapwell, Derbyshire.

(3) May 21, 1958. Minor tremor felt in Leeds, Bradford, Huddersfield and Batley.

(4) June 1, 1958. Three minor tremors (0h. 3m., 0h. 20m., 0h. 24m.) felt at Wetherby, York, Dewsbury, Keighley, Leeds, Bradford, Barnsley and Castleford.

SEISMOLOGY IN THE INTERNATIONAL GEOPHYSICAL YEAR

By Dr. R. Stoneley, F.R.S., National Correspondent for Seismology

So far as seismology is included in the I.G.Y. the outstanding need has been for as many stations in the world as possible to read their records and compile bulletins without delay, and to send these bulletins to the three world data centres, which for seismology are at Washington, D.C., Moscow and Strasbourg. This activity can easily cause a strain on the small staff of an observatory, and it is gratifying that our observatories in the United Kingdom have continued to send in their data promptly. It will be impracticable for all our stations to carry out the heavy task of compiling bulletins of microseismic data.

The seven stations in the West Indies, Antigua, Barbados, Dominica, Granada, St. Lucia, St. Vincent and Trinidad, are co-operating in this work, and it is of interest to learn that an Assistant Seismologist, Mr. K. G. Barr, at present Lecturer in Physics at Khartoum, has been appointed to help Dr. G. R. Robson, Seismologist at Trinidad.

Telegrams have been received regularly at the Royal Society from their station at Halley Bay, Antarctica. These messages are sent in the International Seismological Code, and give the times of two prominent onsets (*i* or *e*) in each shock, together with azimuth of reception (if determined), and depth of focus where known. These messages are decoded at Cambridge, which has been designated the National Centre for Seismology during the I.G.Y.; the bulletins prepared from these readings are sent to the three world data centres, to the International Seismological Summary, and in addition to some ten institutions specially interested in receiving data from stations in the Polar Regions.

It should be mentioned that two stations have been established in Antarctica by the Falkland Islands Dependencies Survey. These stations, Argentine Is. and Port Stanley (Falkland Islands), are equipped with Willmore seismographs, and it is hoped that they will be operated as permanent stations. Records for the first three months of 1958 have been received in London, and it is intended that readings will be transmitted in due course to World Data Centres as part of the U.K. contribution to the I.G.Y.

EUROPEAN SEISMOLOGICAL COMMISSION

By Ernest Tillotson

The European Seismological Commission met at Utrecht from April 8 to 12, 1958. The list of participants from most of the European and circum-Mediterranean countries included fifty-nine names, amongst them Sir H. Jeffreys, F.R.S., Dr. R. Stoneley, F.R.S., and Mr. E. Tillotson.

An account of the meeting was sent to *Nature*, and the resolutions passed at the end of the meeting were:

1. The European Seismological Commission, meeting in Utrecht on the 8th April 1958, has studied in detail the plan involving big explosions which are to be put into operation in the French Alps during the summer of 1958. Numerous teams from many European countries (Germany, France, Great Britain, Italy, Sweden, etc.) will participate in the seismic recording.

The E.S.C. calls the attention of the government authorities to the scientific interest in these experiments which will constitute the second phase in the study undertaken in 1956 of the deep structure of the Alps.

2. The E.S.C. meeting in Utrecht on 8 April 1958 notes with great interest the plan for the great and deep explosion which will be carried out in Belgium.

The E.S.C. is resolved to lend its support for the scientific organisation and for the seismic observation of this experiment.

3.—(1) The E.S.C. recommends that a symposium on seismotectonic problems and on the methods of making a seismotectonic map of Europe be organised during the next meeting of the E.S.C.

It is recommended that the programme of the symposium should include:

(a) reports of representatives from different countries about the studies of the relationships between seismicity and regional tectonics.

(b) the presentation of the principles of the methods of making a seismotectonic map of Europe and a discussion of these principles.

(c) the presentation of technical propositions about the composition of the seismotectonic map (contents, legend, scale, etc.) and their discussion.

(d) the discussion of questions of organisation and elaboration of practical measures to ensure the development of the work.

(2) The E.S.C. considers necessary the establishment of direct relations with the commission for the tectonic map of the International Geological Congress for the success of this work.

(3) Considering that in the U.S.S.R. there is already experience in the making of seismotectonic maps, and that the commission for the tectonic map has its secretariat in Moscow, the E.S.C. charges Professor Beloussov

(a) to establish the contact indicated above with the commission for the tectonic map and to investigate the means for most effective relationship with the commission.

(b) to formulate the principles for the composition of the seismotectonic map of Europe and circulate these amongst the participating countries of the E.S.C.

(c) to prepare, in collaboration with Professor Båth, as joint rapporteurs, the symposium on the composition of the seismotectonic map of Europe at the next session.

4. Considering the great advantages presented by homogeneous sets of seismographs for the solution of numerous seismological problems, the E.S.C. recommends that:

(1) All seismological stations which already possess Galitzin or Galitzin-Wilip seismographs, or other long-period seismographs, complete their equipment so that they will have a set of three components regulated in a manner as nearly the same as possible (the same frequency characteristics for the three components).

(2) The stations indicated below complete their equipment or acquire sensitive long-period seismographs so that they will have a set of homogeneous instruments: Spitzbergen, Reykjavik, Bergen, Dublin, Prague, Azores, Algiers.

EDINBURGH SEISMOGRAMS

The Secretary has completed the arrears by reading these seismograms up to June 1957, and has continued for the I.G.Y.

ASSEMBLY OF CORRESPONDING SOCIETIES—SECTION X GLASGOW, 1958

THE President of the Section (Rt. Hon. Lord Boyd Orr, D.S.O., M.C., LL.D., F.R.S.) welcomed members on the morning of Thursday, August 28, and introduced the opening speaker in the person of Dr. W. E. Swinton, who took as his subject 'Darwin in Scotland' (see p. 201), this being at the time when the great scientist attended Edinburgh University at the age of seventeen years in 1825–6, along with his brother Erasmus.

The following session was devoted to 'Field studies in the Loch Katrine area', presented as a preliminary to the Sectional excursion to take place two days ahead, by Mr. B. W. Ribbons and Dr. Stuart M. K. Henderson. The former dealt with the flora of The Trossachs, through which members would be passing, an area which awaited more detailed study, and spoke of The Scottish Field Studies Association and its need for field study centres on a scale comparable with those to be found in England and Wales, where they play an important part in school and university education. This is not so in Scotland to any extent; the lack of funds to form suitable centres being the obstacle. When this can be overcome it is hoped to provide a main field centre, possibly at Glencoe. Dr. Henderson followed with a well illustrated account of the Dalradian rocks and an interpretation of the geological structures around Loch Ard and Loch Katrine.

The Rt. Hon. Lord Boyd Orr delivered his stimulating Presidential Address in the afternoon, taking as his subject 'The cultural value of local societies'.

On Friday morning, August 29, a large audience heard four speakers dealing with 'The Presentation of Science', following an introduction by the President of the Section, who stressed the importance of adapting oneself to audiences of differing ages and knowledge of the subject matter. Mr. Marcus Morris then considered presentation to junior audiences and the importance of approaching these at their own level of understanding, with content to feed the imagination, and of how to develop in them a right attitude to both science and scientist. Practical aspects of the task were discussed. Mr. P. Ritchie Calder, C.B.E., then put forward the presentation to adult audiences of non-scientific character, noting the long history of such achievement by members of the British Association from its earliest days, when men of the calibre of Sedgwick, Huxley, Thompson and Perry when addressing such audiences found that members understood and applauded, not that people took a more intelligent interest in science in those days, but that science itself was more intelligible by reason of the way it was expounded. 'Today', said the speaker 'science which exists to rebut magic and disprove superstition is in danger of creating a new superstition', meaning that the public of the present also require scientific facts to be explained in language which can be understood, but 'the technique of presenting science to adults not well versed in the subject is a much more difficult matter than presenting it to school children, or to teenagers. For one thing, adults have not grown up as the youngsters have with an awareness of great discoveries; they are rather bewildered by things which the younger generation take for granted.' Mr. L. J. F. Brimble followed with views on the presentation 'By scientist to scientists in differing subjects'. He made a plea for the use of simpler terms, even when one scientist is speaking to another whose subject differs from that of the exponent. When press reporters are present, along with ordinary members of the public, they can be confronted with unintelligible abbreviations,

in place of the lengthy words once used so generously and as little understood; but when one scientist cannot understand another how can laymen be expected to do so? If science as now presented is to have any meaning at all to those not conversant with the subject—which applies equally to that in both oral and written form—the exponent should be prepared to reach down to a level befitting to his audience, or reader. The concluding address was given by Miss F. R. Elwell on the presentation of science 'Through the medium of television'. Miss Elwell explained the method of approach adopted by The British Broadcasting Corporation to varying scientific subjects and illustrated her remarks by means of a series of excellent films. The afternoon was devoted to a conference of delegates representing the many local scientific societies affiliated to the British Association. A host of relevant subjects was reviewed, and a clear account presented by Mr. R. A. Stevens (Assistant Secretary of the Association) of the scheme now being formulated by the Association whereby its activities will range throughout the United Kingdom, and throughout the year too, so as to present science in an acceptable form to the younger generation—both to stimulate their interest and to encourage them to adopt it as a career.

The Southern Highlands and Loch Katrine were visited on Saturday, August 30, when Dr. S. M. K. Henderson and Mr. J. G. Scott led a very successful excursion.

On the morning of Monday, September 1, Mr. J. G. Scott presented, under the title of 'Local societies and archaeological research in Scotland', a summary of exceptional activity of 'members imbued with the desire to do something positive', and who 'over the years have produced a crop of local guides and histories which still can produce items of archaeological information unobtainable elsewhere'.

This was followed by an exceptionally well-illustrated address on 'Marine biology at Millport', given by the Director of the well-known Biological Research Station at Millport, Dr. C. H. Mortimer, F.R.S.

During the afternoon an excursion along the Clyde Valley was undertaken, again under the leadership of Dr. Henderson and Mr. Scott, culminating in a visit to the site of the Castledykes Roman fort, near Carstairs.

What now has become an accepted feature of the Section X programme—'Science by the upper form'—occupied the morning of September 2, when five boys from both public and grammar schools discoursed. The first two formed a team when Mr. Albert M. J. Hutchins and Mr. Andrew J. Nicholl presented the outcome of a piece of work recently performed on the 'Plant ecology of heather, moor, and bog', in Scotland. Mr. Alan Nicol followed with a paper on 'The production of special steels', being succeeded by Mr. J. C. Natzio who, having taken part in work done by R.R.S. *Discovery II* earlier in the year, gave an account of methods adopted in order to obtain study material, often from great depths, and to ascertain the physical properties of the seas in which the ship operated. The final speaker was Mr. D. W. McCredie, on 'The breeding habits of the hen harrier in south-western Perthshire'. Throughout, a series of slides, films and specimens were used, and once again what the young people had to tell amply proved how important it is that their age group should receive the notice of seniors in matters of science, and that the latter should be in a position to appraise work done by juniors.

An excursion to the Rolls-Royce aircraft engine works at East Kilbride concluded the programme of Section X. This was a visit of very considerable interest, and the reception given and hospitality extended by our hosts was greatly appreciated.

GENERAL TREASURER'S STATEMENT AND ACCOUNT 1957-58

It is pleasant, after so long, to be able to record a surplus. Although the financial problems of the Association are not yet solved permanently, the first steps towards their solution have been taken successfully. What has happened is that certain firms have very generously given us money, for a period, to be spent, during that period, on specific activities. Not all of it has been used up this year—hence the surplus—but the rate of activity can be expected to build up.

There are some increases in expenditure. These are due mainly to two causes—the distance of the annual meeting in Dublin and the recruitment of staff. The cost of two activities do not bear on the Association's funds, viz., the Science and Industry Committee and the Directory of Natural History Societies. The Corcoran Fund, given anonymously in memory of Miss J. R. Corcoran, has been used up, through the Society of Antiquaries, towards the cost of a map of part of the Eastern Desert of Egypt.

The year's record has shown that the extension of the work of the Association is being effective in demonstrating that financial support for the Association will be fruitful. It is therefore confidently expected that a widening of the Appeal which was begun during the year will succeed in paying for the activities contemplated in the next few years; and that, with the reputation of the Association widely recognized, means will be found of establishing its income adequately and permanently.

The Association owes much gratitude to all members of the staff, both old and new, on whom has fallen the brunt of the work involved in all this development. There will no doubt be satisfaction that more convenient accommodation has now been found for them.

An appeal has been lodged against the decision of the Inland Revenue Authorities disallowing our claim for the return of income tax on covenanted subscriptions and legal advice is being taken.

M. G. Bennett,
General Treasurer

Balance Sheet, 31st March, 1958

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

	LIABILITIES	£ s. d.	£ s. d.		ASSETS	£ s. d.	£ s. d.
	L. PURPOSES :—				**GENERAL PURPOSES :—**		
	ry Creditors	2,352 12 10			Investments as scheduled with Income and Expenditure Account, No. 1	51,372 13 9	
	ms received in advance for blications	334 11 0			Sundry Debtors	385 9 0	
	bership and Associateship scriptions in advance	163 3 0			Cash and stamps in hand	26 15 10	
	ney temporarily held on behalf Seismological Investigations mmittee (Dr. J. E. Crombie's quest)	500 0 0			Cash at bank—		
			3,350 6 10		On deposit	4,000 0 0	
					On current account	90 14 6	
	lated Fund						
	er last Account	39,092 12 11					
	Legacy by Miss C. A. Jacobsen	500 0 0					
			39,592 12 11				
	Revenue Reserve Account						
	nsfer from Income and Expenditure Account		3,797 18 0				
			46,740 17 9				
	bership Fund						
	er last Account	8,956 5 4					
	Subscriptions received during year	178 10 0					
			9,134 15 4				
[5 4]			55,875 13 1	*[51,796 5 4]*			55,875 13 1
	ment Fund				*Development Fund*		
	er last Account	6,642 7 0			Investments (see Income and Expenditure Account, No. 2)	6,108 1 5	
	Excess of Expenditure over come for the year	302 7 6			Cash at bank	231 18 1	
7 9]			6,339 19 6	*[6,642 7 0]*			6,339 19 6
12 4]			£62,215 12 7	*[58,438 12 4]*			£62,215 12 7
	L. PURPOSES :—				**SPECIAL PURPOSES :—**		
	Fund				*Caird Fund*		
	tal	9,511 9 11			Investments (see Income and Expenditure Account, No. 3)	10,311 9 11	
	me and Expenditure Account balance er last Account	983 14 4			Cash at bank	172 13 3	
	Excess of Expenditure over Income for year	11 1 1					
		972 13 3					
4 3]			10,484 3 2	*[10,495 4 3]*			10,484 3 2
	Hobson Fund (1933)				*Bernard Hobson Fund* (1933)		
	tal	1,093 2 6			Investments (see Income and Expenditure Account, No. 4)	1,393 2 6	
	me and Expenditure Account balance er last Account	392 19 0			Cash at bank	127 14 2	
	Excess of Income er Expenditure for year	34 15 2					
		427 14 2					
1 6]			1,520 16 8	*[1,486 1 6]*			1,520 16 8
	and Leicestershire Fund (1933)				*Leicester and Leicestershire Fund* (1933)		
	tal	1,000 0 0			Investments (see Income and Expenditure Account, No. 5)	1,150 0 0	
	me and Expenditure Account balance er last Account	247 6 8			Cash at bank	63 8 7	
	Excess of Expenditure over Income the year	33 18 1					
		213 8 7					
6 8]			1,213 8 7	*[1,247 6 8]*			1,213 8 7
	Mather Lecture Fund (1936)				*Radford Mather Lecture Fund* (1936)		
	tal	242 18 0			Investment (see Income and Expenditure Account, No. 6)	242 18 0	
	me and Expenditure Account balance er last Account	52 19 8			Cash at bank	60 6 4	
	Excess of Income er Expenditure for year	7 6 8					
		60 6 4					
8]			303 4 4	*[295 17 8]*			303 4 4
10 1]	Carried forward		13,521 12 9	*[13,524 10 1]*	Carried forward		13,521 12 9

Balance Sheet, 31st March, 1958 (*continued*)

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparis

LIABILITIES (*continued*)

		£ s. d.	£ s. d.
[13,524 10 1]	Brought forward		13,521 12 9
	Arthur Haydock Bequest **(1945)**		
	Capital	2,215 12 0	
	Income and Expenditure Account balance as per last Account . 724 6 1		
	Add Excess of Income over Expenditure for the year . . . 65 9 0		
		789 15 1	
[2,939 18 1]			3,005 7 1
	Directory of Natural History Societies		
	Payments received from Carnegie United Kingdom Trust . .	550 0 0	
	Less Expenditure (see Income and Expenditure Account, No. 8) .	539 9 11	
[– – –]			10 10 1
	Corcoran Gift **(1946)**		– – –
[122 15 7]			
	Science and Industry Committee		
	Balance as per last Account . .	154 1 9	
	Board of Trade grants . . .	440 15 0	
	Department of Scientific and Industrial Research grants . .	1,042 1 5	
	Nuffield Foundation Grants . .	1,650 0 0	
	Queen's University, Belfast . .	32 9 7	
		3,319 7 9	
	Less Amounts transferred to the Committee . . . 3,271 3 2		
	Audit Fee . . . 15 15 0		
		3,286 18 2	
154 1 9]			32 9 7
[16,741 5 6]			£16,569 19 6

ASSETS (*continued*)

		£ s. d.	£ s. d.
[13,524 10 1]	Brought forward		13,52
	Arthur Haydock Bequest **(1945)**		
	Investments (see Income and Expenditure Account, No. 7) .	2,865 12	
	Cash at bank	139 15	
[2,939 18 1]			3,00
	Directory of Natural History Societies		
	Cash at bank	7 16 7	
	Cash in hand	2 13 6	
[– – –]			1
	Corcoran Gift **(1946)** (see Income and Expenditure Account, No. 9)		
[122 15 7]			
	Science and Industry Committee		
	Cash at bank . . .	32 9 7	
[154 1 9]			32
[16,741 5 6]			£16,569

We have examined the foregoing Account with the Books and Vouchers and certify the same to be correct. We have also v the Balance at the Bankers and the Investments.

Approved:
H. J. T. ELLINGHAM
HARRY G. MAULE
Auditors.

W. B. KEEN & CO., *Chartered Accountants*,
Finsbury Circus House, Blomfield St.,
11th Jun

INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31st MARCH, 1958

No. 1. General Income and Expenditure

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.	£ s. d.
	Investments at cost :		
	£8,264 4s. 4d. Consolidated 2½ per cent. Stock	6,401 3 0	
	£1,999 0s. 4d. British Gas 3 per cent. Stock, 1990/95	1,520 14 10	
	£18,400 0s. 0d. 3 per cent. Savings Bonds, 1965/75	19,098 11 9	
	£52 12s. 7d. 3½ per cent. War Stock (Post Office issue)	54 5 2	
	£7,704 6s. 2d. 3½ per cent. War Stock	7,840 0 9	
	£6,768 15s. 7d. 3½ per cent. Conversion Stock, 1961 or after	5,726 8 11	
	£4,184 18s. 2d. 2½ per cent. Treasury Stock, 1975 or after	4,184 18 2	
	£1,400 0s. 0d. 4 per cent. Funding Loan Stock, 1960/90	1,622 0 0	
	£981 10s. 0d. 4 per cent. Commonwealth of Australia Stock 1955/70	1,000 0 0	
	£4,897 18s. 11d. 3 per cent. British Transport Stock, 1978/88	3,824 11 2	
	£100 0s. 0d. 3½ per cent. Defence Bonds	100 0 0	
[*Value of stocks at 31/3/57, £38,025*]	(Value at 31/3/58, £35,021)		
[*51,372 13 9*]		£51,372 13 9	

EXPENDITURE

	£ s. d.	£ s. d.
[ ] Lighting and Power		122 19 9
[ ] nery		664 4 3
[ ] tenance of Machines		8 16 6
[ ]		1 0 0
[ ]es		642 10 10
[ ]phone		94 16 4
[ ]nces		13 11 3
[ ]elling expenses		1,360 12 4
[ ] for 1956-57		115 10 0
[ ]itioners :	345 7 6	
[ ]ss Contribution by Liverpool University	156 0 0	
		189 7 6
[ ]ription to Parliamentary and [ ]entific Committee		15 15 0
[ ]ription to International Union [ ] the Conservation of Nature [ ] Natural Resources		5 0 0
[ ]g rooms, equipment, etc.		45 5 2
[ ]an Lockyer Lecture fee		10 10 0
[ ]spection and Repairs		20 14 0
[ ]ge of goods		137 3 7
[ ]ence books, press cuttings, etc.		49 17 6
[ ]y expenses		274 14 11
[ ] of armorial bearings		14 13 9
[ ]ific Films at Annual Meeting		167 1 7
[ ]es, wages, pensions and [ ]ional Insurance		6,419 19 5
[ ]g, etc.—		
[ ]he Advancement of Science"	2,803 19 3	
[ ]liminary Programme, 1957	674 4 7	
[ ]gramme, 1957	696 17 8	
[ ]xcellaneous	456 12 7	
		4,631 14 1
[ ]uality		351 2 2
[ ]bership badges		53 0 0
[ ]porary clerical assistance		140 13 6
[*17 1 0*]		£15,550 13 5
[ ]e being excess of Income over [ ]penditure for the year, carried [ ]n		3,797 18 0
[-]		
[*17 1 0*]		£19,348 11 5
[ ]fer to General Revenue Reserve		3,797 18 0
		£3,797 18 0

INCOME

	£ s. d.	£ s. d.
Membership subscriptions		6,975 7 0
Sale of Publications :		
"The Advancement of Science"	934 12 11	
Other items	142 18 2	
		1,077 11 1
Advertisements in B.A. publications :		
"The Advancement of Science"	699 7 11	
Preliminary Programme, 1957	411 12 0	
Programme, 1957	548 10 5	
		1,659 10 4
Income Tax recovered to 31st March, 1957 :		
On Interest and Dividends	79 2 8	
„ Donations under covenant	33 13 1	
		112 15 9
Interest on Investments	1,598 3 0	
„ „ bank deposit	63 0 3	
		1,661 3 3
Donations received: (*Excluding* Income Tax recoverable)		7,615 12 6
Charges for administration of Special Funds		69 16 1
Geographical Photographs Committee, final balance		176 15 5
[*11,181 17 9*]		19,348 11 5
Balance, being excess of Expenditure over Income for the year		- - -
[*1,875 3 3*]		
[*13,057 1 0*]		£19,348 11 5
Balance brought down		3,797 18 0
		£3,797 18 0

No. 2. Development Fund

An Appeal for a Developments Fund to be used under the direction of the Council, was made at the Annual Meeting at Dundee in The fund is still open.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.

		£ s. d.
	Investments at cost :	
	£2,745 19s. 0d. London County 2½ per cent. Consolidated Stock, 1960/70	2,750 0 0
	£3,387 14s. 10d. Savings 3 per cent. Stock, 1965/75	3,028 7 0
	£292 15s. 3d. Consolidated 2½ per cent. Stock	200 0 0
	£175 0s. 0d. 3½ per cent. War Stock	129 14 5
[*Value of stocks at 31/3/57, £4,957*]	(Value at 31/3/58, £4,723)	
[*6,108 1 5*]		£6,108 1 5
	Cash at bank	£231 18 1

	EXPENDITURE	£ s. d.		INCOME	£
	Office alterations, etc.	277 12 0		Interest	190
	Typewriter	65 10 0	[*184 9 2*]	Balance being excess of Expenditure over Income for the year	302
	Furniture, etc.	130 16 0	[– – –]		
	Administration charge	19 1 2			
[*145 15 5*]		492 19 2			
[*38 13 9*]	Balance, being excess of Income over Expenditure for the year	– – –			
[*184 9 2*]		£492 19 2	[*184 9 2*]		£492

No. 3. Caird Fund

The unconditional gift of Sir James Caird, in 1912, administered by the Council in accordance with recommendations adopted by General Committee in 1913.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.

		£ s. d.
	Investments at cost :	
	£2,904 11s. 8d. British Gas 3 per cent. Stock, 1990/95	2,209 13 0
	£2,716 16s. 6d. 3½ per cent. War Stock	2,516 15 5
	£4,282 18s. 9d. 3 per cent. British Transport Stock, 1978/88	4,785 1 6
	£585 10s. 6d. Consolidated 2½ per cent. Stock	400 0 0
	£400 Borough of Watford 5½ per cent. Loan	400 0 0
[*Value of stocks at 31/3/57, £7,035*]	(Value at 31/3/58, £7,008)	
[*9,911 9 11*]		£10,311 9 11
	Cash at bank	£172 13 3

	EXPENDITURE	£ s. d.	£ s. d.		INCOME	£
	Rent of tables at Biological Stations:					
	Naples Zoological Station: for 1958	100 0 0			Interest	277
	Additional rent for 1957	50 0 0			Income Tax recovered	54
	Freshwater Biological Association, Windermere, for 1958	50 0 0		[*325 6 8*]		332
	Marine Biological Association, Plymouth, for 1958	50 0 0			Balance, being excess of Expenditure over Income for the year	11
			250 0 0	[– – –]		
	Grant to Derbyshire Caves Committee		10 0 0			
	Contribution to Myres Memorial Fund		50 0 0			
	Administration charge		33 4 4			
[*217 10 8*]			343 4 4			
[*107 16 0*]	Balance, being excess of Income over Expenditure for the year		– – –			
[*325 6 8*]			£343 4 4	[*325 6 8*]		£343
	Grant authorised, not yet drawn :—					
	Inventaria Archaeologica	10 0 0				
	Ainu of Japan	50 0 0				
	Ancient Field Systems	10 0 0				
[*10 0 0*]		£70 0 0				

No. 4. Bernard Hobson Fund

bequest of Mr. Bernard Hobson, 1933; the income to be applied to the promotion of geological research; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£50 0s. 0d. 4 per cent. Victory Bonds	55 10 5
	£601 9s. 0d. 2½ per cent. Treasury Stock, 1975 or after	601 9 0
	£416 0s. 11d. 3½ per cent. War Stock	436 3 1
	£178 16s. 4d. Consolidated 2½ per cent. Stock	150 0 0
	£150 Borough of Watford 5½ per cent. Loan	150 0 0
[*1,243 2 6*]	[*Value of stocks at 31/3/57, £770*] (Value at 31/3/58, £842)	£1,393 2 6
	Cash at bank	£127 14 2

EXPENDITURE	£ s. d.	INCOME	£ s. d.
inistration charge [*1*]	3 17 3	Interest	38 12 5
ce, being excess of Income over Expendi-e for the year [*9 1*]	34 15 2		
[*9 2*]	£38 12 5	[*36 1 2*]	£38 12 5

authorised, not yet drawn :—
ical Geological Sections 30 0 0

[*9 0*] £30 0 0

No. 5. Leicester and Leicestershire Fund, 1933

unexpended balance of the local fund for the Leicester Meeting in 1933, presented to the Association, the interest to be used in assisting by scholarships or otherwise students working for the advancement of science; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£487 2s. 11d. 3½ per cent. Conversion Stock	500 0 0
	£490 5s. 11d. 3½ per cent. War Stock	500 0 0
	£150 Borough of Watford 5½ per cent. Loan	150 0 0
[*1,000 0 0*]	[*Value of stocks at 31/3/57, £713*] (Value at 31/3/58, £783)	£1,150 0 0
	Cash at bank	£63 8 7

EXPENDITURE	£ s. d.	INCOME	£ s. d.
s	67 0 0	Interest [*34 4 2*]	36 15 5
– –]			
inistration charge [*0*]	3 13 6	Balance being excess of Expenditure over Income for the year [– – –]	33 18 1
ce, being excess of Income over Expenditure for year [*9*]	70 13 6 – – –		
[*4 2*]	£70 13 6	[*34 4 2*]	£70 13 6

No. 6. Radford Mather Lecture Fund

of £250 received from Mr. G. Radford Mather in 1936 to establish a Fund, the income therefrom to be devoted to meeting the expense of triennial Lectures on Recent Advances in Science and their relation to the Welfare of the Community.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost :	
	£271 14s. 6d. Savings 3 per cent. Stock, 1965/75	242 18 0
[*242 18 0*]	[*Value of stock at 31/3/57, £205*] (Value at 31/3/58, £193)	£242 18 0
	Cash at bank	£60 6 4

EXPENDITURE	£ s. d.	INCOME	£ s. d.
istration charge [*0*]	16 4	Interest	8 3 0
e, being excess of Income over Expendi-for the year [*0*]	7 6 8		
[*0*]	£8 3 0	[*8 3 0*]	£8 3 0

No. 7. Arthur Haydock Bequest

A bequest received in 1945 "for the purpose of original investigation of problems relating to either or both of Geology or [illegible] as may be determined by the governing body of the British Association."

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.

		£ s. d.
	Investments at cost :	
	£2,090 4s. 0d. 3½ per cent. Conversion Stock	2,215 12 0
	£362 6s. 3d. Consolidated 2½ per cent. Stock	250 0 0
	£400 Borough of Watford 5½ per cent. Loan	400 0 0
[2,465 12 0]	*[Value of stocks at 31/3/57, £1,709]* (Value at 31/3/58, £1,915)	£2,865 12 0
	Cash at bank	£139 15 1

EXPENDITURE	£ s. d.	INCOME	£
"Geology in Schools" reprints	12 13 6	Interest	89
Postage on above	2 0 4		
Administration	8 18 1		
[68 4 5]	£23 11 11		
Balance, being excess of Income over Expenditure for the year [13 19 11]	65 9 0		
[82 4 4]	£89 0 11	[82 4 4]	£89

No. 8. Directory of Natural History Societies

EXPENDITURE	£ s. d.	INCOME	£
Salary and National Insurance	307 5 8	Cash received from Carnegie United Kingdom Trust	550
Stationery	72 18 5		
Postage, etc.	65 14 5		
Typewriter and mat	65 1 5		
Printing	27 1 8		
Sundry expenses	1 8 4		
	539 9 11		
Balance, being excess of Income over Expenditure for the year	10 10 1		
[– – –]	£550 0 0	[– – –]	£550

No. 9. Corcoran Gift, 1946

A gift of £100 received in 1946 for research in memory of Miss J. R. Corcoran. In accordance with a resolution of the Council in 1957, the capital and accumulated income of the Corcoran Gift have been transferred to the Society of Antiquaries of London contribution towards the cost of a map of part of the Eastern Desert of Egypt.

EXPENDITURE	£ s. d.	£ s. d.	INCOME	£ s. d.	£
Transfer to the Society of Antiquaries of London : £144 18s. 6d. Consolidated 2½ per cent. Stock, at cost	100 0 0		Interest		2
Cash	24 13 11		Transfer of balance of Fund as at 1st April, 1957		122
		124 13 11			
Bank fee in connection with transfer of Stock		10 6			
Administration charge		5 5			
		£125 9 10			£125

REPORT OF COUNCIL TO THE GENERAL COMMITTEE, 1957–58

Obituary

1. The Council have during the last year mourned the passing of Prof. V. Gordon Childe, a past President of Section H (Anthropology and Archaeology); Dr. J. C. Maxwell Garnett, member of Council (1946–50) and Honorary Auditor (1950–51); Sir Alexander Gibb, a past President of Section G (Engineering); Sir John Graham Kerr, a past President of Section D (Zoology) and member of Council (1939–48); Lord Eustace Percy of Newcastle, a past President of Section L (Education), and Dr. J. A. Venn, a past President of Section M (Agriculture) and member of Council (1933–38).

The Council has suffered further loss by the death of the following office bearers and supporters:

Sir Frederick H. Berryman
Mr. E. G. P. Bousfield
Prof. C. H. Bulleid
Mr. Henry Bury
Rt. Hon. Viscount Cherwell
Mr. Frank Christy
Mrs. A. S. Cooke
Mr. Thurkhill Cooke
Dr. O. G. S. Crawford
Mr. A. H. Davidson
Mr. A. F. Dufton
Dr. I. D. Ferguson
Dr. P. Grodzinski
Prof. D. R. Hartree
Dr. L. H. Lampitt
Mr. R. G. K. Lempfert
Mr. C. J. Mather
Mr. J. E. Nicholson
Mr. W. B. Ogilvie
Lt.-Col. M. O'Gorman
Mr. W. R. Purnell
Sir T. K. Rose
Miss O. M. Wade
Mr. J. B. Williams

Relations with other Institutions

2. By the appointment of official representatives and in other ways the Association has maintained cordial relations with scientific institutions at home. Changes in representation during the year include the appointment of Professor E. O. James to represent the Association on the Joint Committee for Anthropological Research and Teaching. Dr. W. E. Swinton and the Secretary represented the Council at an Inaugural Meeting held on February 19, 1958, to discuss the setting up of a 'Council for Nature'. Mr. R. H. Tizard has been appointed to fill a vacancy in the Association's representation on the Science and Industry Committee. Prof. T. N. George has been appointed to serve on the Royal Society's National Committee for Geodesy and Geophysics, Dr. R. W. Powell to the Committee for Physics, and Prof. D. N. de G. Allen to the Committee for Mathematics. Prof. E. H. Neville and Prof. D. N. de G. Allen have been appointed as delegates to the International Congress of Mathematics at Edinburgh in August, 1958.

3. The Council report that they have made a grant of £50 as a donation towards the cost of establishing a Myres Lecture Foundation in the University of Oxford as a memorial to Professor Sir John Myres, and a grant of £100 from the Corcoran Fund to the Society of Antiquaries towards the cost of preparing a map of the Egyptian eastern desert, an area containing many Roman quarries and other sites not previously mapped. A grant of £100 has been made from the Haydock Bequest to the Suffolk Naturalists Society as a contribution to the cost of their Redgrave Fen research project.

4. Having no meeting rooms of its own, the Association is indebted to the Royal Society and the Linnean Society for providing accommodation for Council and Committee Meetings held during the year. The Council also wish to express their appreciation of the generosity of the Principal of the University of London and of the Master of Birkbeck College for putting at their disposal on January 3, 1958, meeting rooms and refectory on the occasion of the installation of the President for 1958 and of combined meetings of all the Section Committees.

5. As regards international relations, the Association's overseas contacts have been well maintained. Under a generous arrangement with the British Council the Association was represented at the Annual Meeting of the Ceylon Association for the Advancement of Science in Colombo in December 1957, by Dr. D. A. Allan, and at the Forty-fifth Indian Science Congress Association Meeting at Madras in January 1958, by Sir Harold Hartley and Dr. Allan. Mr. M. G. Bennett attended the Tenth Pakistan Science Conference in Lahore in March 1958, as the Association's representative.

After consultation with the President and General Officers the Secretary accepted an invitation from the South-East Asia Treaty Organisation to attend a Round-Table Conference in Bangkok as the United Kingdom representative (January 27–February 2, 1958). The Council accepted an invitation to make a nomination for the 'Atoms for Peace Award' (designed to give recognition each year to the individual or group of individuals who had made the greatest contribution to peaceful uses of atomic energy). Congratulatory messages have been sent in the name of the Association to the Presidents of the Academy of Sciences in Moscow and of the National Academy of Sciences in Washington on the occasion of the launching of the first artificial satellites. A number of distinguished overseas scientists, including representatives of sister Associations have been invited to attend the Glasgow Meeting and the Council is pleased to report that among them will be Dr. Alan Waterman, Director of the National Science Foundation, and Dr. Dael Wolfle, representing the American Association for the Advancement of Science; Dr. A. Kohn, Honorary Secretary of the Association for the Advancement of Science in Israel; and Dr. A. Cheve of the French Association for the Advancement of Science.

Unesco

6. The Council is pleased to report that it has made a nomination for the award of the Kalinga Prize for 1958, the purpose of which is to offer recognition of leading interpreters of science and to strengthen the links between India and the scientists of other nations.

7. The Council report also that they have offered twenty complimentary memberships to members of the Overseas Science Students Association in London and to overseas science students at Universities and Colleges in other parts of the country to enable them to attend the Glasgow Meeting.

Finance

8. The General Treasurer has kept the Council informed of the state of the Association's finances and his statement and account for the financial year ending March 31, 1958, will be submitted to the General Committee.

The Council report that they have appointed an Investment Committee to examine the Association's investment policy and to consider the case for taking wider powers of investment. The following have accepted invitations to serve on the Committee: Mr. M. G. Bennett (Chairman), Lord Rennell of Rodd, K.B.E., C.B., Mr. P. A. Macrory, Dr. T. Wilson and Mr. P. F. Carpenter.

9. The Council have to report that the question of covenanted subscriptions has been under review by the Board of Inland Revenue for some time and that tax on these subscriptions which had hitherto been recoverable and which amounts to some £550 per annum has not been received for a period of three years. The Association has been informed that the Board of Inland Revenue do not now consider that repayment is due to the Association in respect of payment made under Deeds of Covenant which comprehend membership subscriptions. The Council, having taken advice from the Association's Solicitors and from Counsel, have agreed to institute an appeal to the Special Commissioners of Income Tax against the determination of the Board of Inland Revenue.

Officers and Council

10. *President*, 1959—The Council will make a recommendation to the General Committee. [Sir James Gray, M.C., C.B.E., F.R.S., was unanimously elected President for 1959.]

11. *General Officers*, 1958–59.—The Council made the following nominations for the year 1958–59, which were unanimously approved:

General Treasurer: Lord Rennell of Rodd, K.B.E., C.B.
General Secretaries: Professor W. Wardlaw, C.B.E., and Dr. N. C. Wright, C.B.

The Council have approved a recommendation received from the Committee appointed by them to nominate the General Officers for the year 1958–59, that General Officers should in future hold office for five years, but that this period could for exceptional reasons be extended to seven years.

12. *Other Members of Council.*—Members retiring under Statute III, 3, are Mr. R. J. Bartlett, Prof. L. F. Bates, Sir Ben Lockspeiser, Prof. A. D. Macdonald and Mr. W. H. Wilcockson. Under the powers given to them by Statutes, the Council nominate for appointment: Prof. R. J. Brocklehurst, Dr. B. J. Mason and Dr. C. J. Stubblefield, leaving two vacancies for the ordinary membership to be filled by the General Committee without nomination by Council. The following is a full list of nominations recommended for approval by the General Committee:

J. N. L. Baker
Prof. R. J. Brocklehurst
Dr. H. O. Bull
Prof. W. Burns
P. Ritchie Calder, C.B.E.
Prof. G. R. Clemo, F.R.S.
Prof. P. Sargant Florence, C.B.E.
Prof. T. N. George
Sir Ronald Gould
A. C. Hartley, C.B.E.
Prof. L. Hunter
Rev. Prof. E. O. James
Dame Kathleen Lonsdale, D.B.E., F.R.S.
James Macdonald, C.B.E.
Dr. B. J. Mason
L. R. Missen, C.M.G., M.C.
Dr. K. P. Oakley, F.B.A.
Dr. C. F. A. Pantin, F.R.S.
Dr. R. W. Powell
Dr. H. G. Sanders
Dr. R. E. Slade
Dr. C. J. Stubblefield, F.R.S.
Dr. W. E. Swinton
Sir James Turner
Dr. W. B. Turrill, O.B.E., F.R.S.
Prof. P. E. Vernon
Dr. T. Wilson, O.B.E.
Prof. S. W. Wooldridge, C.B.E.

[The General Committee approved the above nominations and appointed Prof. O. A. Saunders, F.R.S., and Dr. H. G. Maule to fill the remaining vacancies.]

13. *Honorary Auditors*, 1958–59.—The Council recommend the appointment of Dr. H. G. Maule and Dr. D. B. Harden.

14. *Professional Auditors*, 1958–59.—The Council recommend the reappointment of W. B. Keen and Co.

General Committee

15. The following have been admitted to membership of the General Committee on the recommendation of the Council and Section Committees:

Section	
—	P. H. Schwarzschild
—	Dr. B. K. Hutton
A	Prof. J. D. McGee
B	Dr. E. Philbin, E. R. Stuart
D	Dr. E. J. Ambrose
E	Prof. E. W. Gilbert, N. Stephens, Prof. A. C. O'Dell, Prof. J. Wreford Watson
M	A. R. Wannop, E. Rea

Annual Meetings

Sheffield Meeting, 1956

16. The Council wish to record their gratitude to the Local Committee for the Sheffield Meeting in 1956 for the gift of a copy of a film record of the Annual Meeting in that year.

Dublin Meeting, 1957

17. The attendance at the Dublin Meeting was 3,166, a figure which includes 1,047 local members and some 800 student members. A narrative account of the Meeting appeared on pages 153–8 of the December 1957 issue of *The Advancement of Science*.

Glasgow Meeting, 1958

18. Sir Alexander Fleck, K.B.E., F.R.S., was installed as President for the year at a General Assembly of the Committees of Sections held in the Beveridge Hall, Senate House, University of London, on Friday, January 3, 1958. The text of the Address delivered by the President on the occasion of the installation is printed in full on pages 277–81 of the March 1958 issue of *The Advancement of Science*.

19. The Council gratefully acknowledge the willing and generous assistance given by Local Officers in making preparations for the sixth Meeting in Glasgow which, they are assured, will be a worthy successor to previous meetings in the City. The Council is deeply indebted to the Local Committee for their generous decision to publish a scientific survey of 'Glasgow and its region' and to make it available to all members present at the meeting. A special programme for young people at Glasgow has been arranged in conjunction with the Director of Education and the University authorities. The programme will include a Schools Science Exhibition, a number of special exhibitions, an 'Open Forum', screening of specially selected scientific films and twelve illustrated lectures. Audiences of something like 1,000 children between the ages of 13 and 17 are expected to attend daily from schools in Glasgow and the West of Scotland. It is hoped that sufficient experience will be gained at Glasgow to enable the planning of a major Junior British Association Meeting to be undertaken during 1959.

The Council have approved the appointment of Mr. L. G. Watt, Finance Officer of the University, as Local Honorary Treasurer.

York Meeting, 1959

20. The General Committee have already accepted an invitation to hold the Annual Meeting in 1959 in York. The Council recommend for acceptance a proposal that the Meeting be held from Wednesday, September 2, to Wednesday,

September 9, 1959. The Council are honoured to learn that the Right Hon. The Lord Mayor of York for the time being, will act as Chairman of the Local Executive Committee in York and Councillor J. Durkin and Mr. J. Dronfield as Deputy Chairmen. The Council have appointed the following Local Honorary Officers:

Treasurer: Mr. B. Littlefair (City Treasurer).

Secretaries: Mr. T. C. Benfield (Town Clerk), Mr. H. Oldman (Chief Education Officer).

The Council have agreed to award honorary membership for the Glasgow Meeting to each of the Local Sectional Secretaries for 1959 and to make a grant of £10 to each of them as a contribution towards their expenses in attending that Meeting.

21. The following have accepted the Council's invitation to serve as Presidents of Sections at York:

Section		*Section*	
A	Prof. L. F. Bates, F.R.S.	I	Prof. A. Hemingway
B	Prof. M. Stacey, F.R.S.	J	Prof. Magdalen D. Vernon
C	Prof. O. M. B. Bulman, F.R.S.	K	Dr. W. R. G. Atkins, C.B.E., O.B.E. (Mil.), F.R.S.
D	Dr. Harrison Matthews, F.R.S.		
E	Prof. K. C. Edwards	L	Sir James J. Robertson, O.B.E.
F	Prof. J. Jewkes		
G	Sir Ewart Smith, F.R.S.	M	Dr. H. G. Sanders
H	Prof. I. Richmond, F.B.A.	X	The Countess of Albemarle

Cardiff Meeting, 1960

22. The General Committee have accepted an invitation to hold the Meeting in 1960 in Cardiff. The Council have appointed the following Local Honorary Officers:

Treasurer: The City Treasurer.

Secretaries: Mr. S. Tapper-Jones (the Town Clerk), Mr. R. Evans (The Registrar, University College, Cardiff).

New Activities

23. The General Committee were informed at Dublin that as a result of the generosity of a small number of industrial donors the Association would have an additional income of something like £8,000 in the coming year. An interim report on the progress of the new activities, the planning of which, it was envisaged, would be made possible by this additional income is presented below. The Council wish to make it clear that in seeking these new ways of presenting science to a wider public—and thereby of fulfilling its original functions—it does not wish to give the impression that in any way it underrates the important work now being done in this field by many agencies. The activities of the Royal Institution, the Extra-Mural Departments of the Universities, the Workers' Educational Association, the Schools, Local Societies and many other national and local organisations—to say nothing of the press and the broadcasting and television authorities—are of vital importance. The intention of the Association is to help to fill such gaps as exist, to co-operate with other organisations where such co-operation is desired, and to help in the co-ordination, on a national basis, of this urgent task of presenting and disseminating facts about science to the public at large. The Council have appointed the Committee of the Division for the Social and International Relations of Science to be responsible for all inter-meeting activities.

24. *General Purposes and Finance Committee.*—A General Purposes and Finance Committee was appointed to consider matters of policy and, in particular, pro-

posals for the future activities of the Association. The membership of the Committee is as follows: President and General Officers (ex-officio), Lord Rennell of Rodd, K.B.E., C.B., Mr. P. A. Macrory and Dr. D. C. Martin.

25. *Staff.*—Mr. J. M. Robertson has been given the title of Deputy Secretary; Mr. R. A. Stevens has been appointed as Assistant Secretary to the Association.

26. *Office Accommodation.*—The needs of the learned societies accommodated in Burlington House have been under review by the Office of the Lord President of the Council and it has been accepted that the immediate need of the Association for additional accommodation is urgent. The Treasury has agreed that it will provide such accommodation and that it will pay on the Association's behalf and in its name, and for a period of three years in the first place, the rent, rates and the cost of external repairs to offices at No. 18 Adam Street belonging to the Royal Society of Arts, on the understanding that the Association vacates its present rooms in Burlington House. The new premises will give the Association more than twice its present office accommodation and will include adequate storage space in the basement of the building. The limitation of three years is designed solely to cover the eventuality that within that period other accommodation which might be suitable might be provided by the Treasury in a government building. The Council wish to express their appreciation to the Lord President of the Council for making this accommodation available and to the Council of the Royal Society of Arts for making it possible for the Association to become their tenants.

27. *Lectureships for Young Scientists.*—The Council report that they have established three Lectureships to be delivered by young scientists, to be known as the Kelvin, Darwin and Lister Lectureships. The Committee of Sections have been invited to make nominations in time for the York Meeting in 1959. The purpose of these lectureships is to encourage the younger scientist to convey in non-specialist language to intelligent people what he is doing and why, and so to contribute to the Association's efforts to make the natural sciences and the scientific method understood and accepted by a wider public. The conditions of award of these lectureships are given in full in Appendix 'A'.

28. *Science in Schools.*—A most successful conference on Science in Schools was held in the hall of the Royal Geographical Society in London on April 17 and 18. The Council wish to record their gratitude to the Council of the Royal Geographical Society and to the Officers of the many other organisations who contributed to the planning of the Conference. A large audience representative of headmasters, science masters and mistresses, local education authorities and committees, Universities, Technical Colleges and Training Colleges for Teachers attended the Conference which was opened by Lord Heyworth, Chairman of Unilever Ltd. The Council were honoured also by the presence of Lord Tedder who in a final summing up, gave his views on what had been said by the main speakers and during the most illuminating discussions which followed each session. The Council are pleased to report that Messrs. Butterworths, the publishers of the journal *Research*, have most generously agreed to publish a full report of the conference at their own expense. A programme of the Conference is attached as Appendix 'B'.

29. *Area Committees.*—The Council have authorised the setting up of a number of prototype Area Committees. They feel that such committees are essential to the success of their plans for the wider presentation of science to the general public since they will enable full advantage to be taken of local knowledge and experience and will make possible invaluable co-operation at a regional level with a number of interested national organisations which themselves have branches throughout the country. It is intended that each Area Committee will have a nucleus of

scientific members of the Association and will include representatives of universities and schools, of women's and youth organisations, technical colleges, industry, trade unions, history societies, Rotary Clubs and so on. The Council believes that while such Committees will be essentially individual in character and may vary in their organisation and efforts according to local circumstances, they will have a common purpose and a common identification with the British Association. Some financial support will be necessary to enable Committees to work effectively and a maximum figure of £500 per Committee per year—to cover fees and expenses of lecturers and secretarial expenses—has been suggested. The Council are of the opinion that for such relatively small sums remarkably effective results will be attained.

The first Committee is in the process of formation on Tees-side and discussions with the aim of establishing similar Committees in the Newcastle area (under the auspices of the Extra-Mural Department of the University) and in Hertfordshire, East Anglia, Durham, Cornwall, South Wales, Bristol and Clydeside are making good progress.

30. *Lectures.*—Plans to encourage—by lectures and in other ways—the presentation of science in districts in which Area Committees are not contemplated are well advanced. Invitations to join the Association's panel of lecturers have been sent to nearly 200 scientists and about 100 have already accepted. Great care will be taken in the development of this lecture service to ensure that the quality of the lectures and the standards of presentation (including the use of visual aids and demonstrations) shall be in accordance with the traditions of the Association. The first of the many lectures now being planned was given at Ipswich on February 25, 1958, by Professor J. Rotblat—to some 900 school children—on the peaceful uses of atomic energy. The lecture, which was very greatly appreciated, was the fruit of a most welcome and successful collaboration between the Association, the Atomic Scientists' Association, the Atomic Energy Authority and the Education Authorities of Ipswich and East Suffolk. Although the lecture service will not begin to operate fully until September a number of special lectures on the Ipswich pattern have already been arranged and will be given during May, June and July.

31. *Atomic Scientists' Sub-Committee.*—As a result of negotiations between the Council and the Council of the Atomic Scientists' Association, it has been agreed that an Atomic Scientists' Sub-Committee of the Division for the Social and International Relations of Science should be set up and that its terms of reference should be 'to bring before the public of the United Kingdom the facts about atomic energy and their implications'.

Council has approved the following list of members of the Sub-Committee. *British Association members*: Sir Ben Lockspeiser (Chairman), Prof. W. Wardlaw, Dr. D. C. Martin; *nominated by the Atomic Scientists' Association*: Prof. G. O. Jones, Prof. J. Rotblat, Mr. B. T. Price, Dr. H. R. Allan and Mr. E. H. Underwood. The Council welcomes this opportunity for collaboration and is of the opinion that it offers great advantages especially at the present time when the Association is itself engaged on developing new ways of communicating some of the results and significance of science to a wider public.

32. *Study Group on the Education of the Graduate Scientist in School and University.*—The Council are glad to report that Dr. R. P. Linstead, F.R.S., Rector of the Imperial College of Science and Technology, has accepted their invitation to direct, as Chairman, the work of a study group which they have set up to consider the education of the graduate scientist in school and university. The purpose of the enquiry is to consider whether it is desirable to broaden the education of those intending to become professional scientists and technologists, if so,

how and at what stage; whether this is compatible with the present overall length of education; and, if an extension is desirable, how this is to be achieved and whether it should be general or confined to selected classes of students; and the financial implications. It is expected that the enquiry will be completed in roughly 18 months and negotiations are in progress to secure the necessary funds to enable the work to proceed. It is hoped to make a further report to the General Committee at the Annual Meeting in Glasgow.

33. *Study Group on the Metric System.*—The Council wish to report that they have sent up a Study Group on the Metric System and that Sir Hugh Beaver, K.B.E., has honoured them by agreeing to act as Chairman. The following have accepted invitations to serve on Sir Hugh Beaver's Committee: Dr. A. H. Hughes (Deputy Chairman), Assistant Managing Director, Arthur Guiness, Son & Co. Ltd.; Dr. R. Beeching, Director of Imperial Chemical Industries; Mr. M. G. Bennett, General Treasurer, British Association; Prof. C. F. Carter, Professor of Applied Economics, Queen's University, Belfast; Mr. Hugh Conway, Joint Managing Director, Short Brothers and Harland Ltd.; Mr. A. C. Hartley, C.B.E., Consulting Engineer; Mr. F. S. Walker, M.C., Chairman of Lever Brothers, Port Sunlight, Ltd.; Mr. C. P. Jones, Rolls Royce Ltd.

It is hoped that the Committee, whose terms of reference are given below, will make their report to the Council in about eighteen months' time:

(i) To report on the practicability, implications, consequences both international and domestic, and the cost of a change-over to the metric system or the decimalisation of weights, measures and coinage by the United Kingdom.
(ii) To obtain such information as is necessary for the purpose of the enquiry by taking evidence, by visiting firms and organisations or by any other means.
(iii) To appoint the necessary full-time staff.
(iv) To expend the funds placed at the disposal of the Committee for the purposes of the investigation.
(v) To take any other steps which are considered necessary for the enquiry.
(vi) To submit brief quarterly interim reports of the progress of the investigation to the Council.

Research Committees

34. Following the Dublin Meeting the Council appointed ten Research Committees on the recommendation of Sections and made grants to four of them from the funds under their control. The Committees, with their terms of reference and membership are listed below:

SECTION A.—MATHEMATICS AND PHYSICS

Seismological investigations.—Dr. R. Stoneley, F.R.S. (*Chairman*), Mr. E. Tillotson (*Secretary*), Mr. E. F. Baxter, Miss E. F. Bellamy, Prof. P. G. H. Boswell, O.B.E., F.R.S., Mr. B. C. Browne, Sir Edward Bullard, F.R.S., Dr. K. F. Chackett, Dr. G. E. R. Deacon, F.R.S., Dr. A. T. J. Dollar, Dr. A. E. M. Geddes, O.B.E., Prof. G. R. Goldsbrough, C.B.E., F.R.S., Dr. M. N. Hill, Mr. J. S. Hughes, Sir Harold Jeffreys, F.R.S., Dr. E. R. Lapwood, Rev. C. Rey, S.J., Dr. G. D. Robinson, Dr. N. A. Routledge, Mr. H. V. Shaw, Sir Frank Smith, G.C.B., G.B.E., F.R.S.

SECTION C.—GEOLOGY

To excavate critical geological sections in Great Britain.—Mr. W. H. Wilcockson (*Chairman*), Mr. J. M. Edmonds (*Secretary*), Sir Edward Bailey, M.C., F.R.S., Mr. J. L. Begg, Mr. W. S. Bisat, F.R.S., Prof. P. G. H. Boswell, O.B.E., F.R.S., Prof. A. H. Cox, Dr. E. E. L. Dixon, Prof. W. G. Fearnsides, F.R.S., Prof. T. N. George, Prof. H. L. Hawkins, F.R.S., Dr. R. G. S. Hudson, Prof. V. C. Illing, F.R.S., Prof. O. T. Jones, F.R.S., Dr. Murray Macgregor, Mr. T. G. Miller, Prof. L. R. Moore, Dr. F. J. North, O.B.E., Prof. F. W. Shotton, M.B.E., F.R.S., Dr. W. E. Swinton, Dr. F. S. Wallis, Prof. D. M. S. Watson, F.R.S., Prof. T. S. Westoll, Prof. W. F.

Whittard, F.R.S., Prof. S. W. Wooldridge, C.B.E. **£30.**

To consider and report on questions affecting the teaching of geology in schools.—Prof. T. N. George (*Chairman*), Dr. Mabel E. Tomlinson (*Secretary*), Prof. J. G. C. Anderson, Miss M. A. Arber, Mr. A. Bray, Prof. W. G. Fearnsides, F.R.S., Dr. J. F. Kirkaldy, Prof. L. R. Moore, Mr. J. Myers, Prof. Sir William Pugh, O.B.E., F.R.S., Dr. K. S. Sandford, Dr. S. H. Straw, Dr. Dighton Thomas, Dr. A. K. Wells, Prof. A. Wood.

SECTIONS C, K.—GEOLOGY, BOTANY

The investigation of Coal Ball Flora, by Dr. H. S. Holden.—Dr. G. Taylor (*Chairman*), Prof. T. M. Harris, F.R.S. (*Secretary*), Dr. A. W. Woodland.

SECTIONS D, K.—ZOOLOGY, BOTANY

Co-ordinating committee for Cytology and Genetics.—Prof. K. Mather, F.R.S. (*Chairman*), Mr. Watkin Williams (*Secretary*), Prof. D. G. Catcheside, F.R.S., Dr. J. L. Crosby, Prof. Sir Ronald Fisher, F.R.S., Prof. P. C. Koller, Dr. P. M. Sheppard, Dr. J. M. Thoday.

SECTION E.—GEOGRAPHY

To prepare a glossary of geographical terms with agreed definitions in English, including reference to origin and to current use and misuse.—Prof. L. Dudley Stamp, C.B.E. (*Chairman*), Mr. G. R. Crone (*Secretary*), Prof. H. C. Darby, Prof. W. G. East, Mr. E. O. Giffard, M.B.E., Mr. A. F. Martin, Prof. A. A. Miller, Dr. C. J. Robertson, Mr. C. T. Smith, Dr. G. T. Warwick, M.B.E., Prof. S. W. Wooldridge, C.B.E., Mr. R. A. Skelton.

SECTION H.—ANTHROPOLOGY

To co-operate with a committee of the Royal Anthropological Institute—in the exploration of caves in the Derbyshire district.—Mr. M. C. Burkitt (*Chairman*), Mr. A. Leslie Armstrong, M.C. (*Secretary*), Mr. J. Bartlett, Dr. Arthur Court, Prof. J. H. Fleure, F.R.S., Dr. J. Wilfrid Jackson, Mr. R. U. Sayce.

To assist in the work of compiling an *Inventaria Archaeologia* as part of an international enterprise sponsored by the International Congress of Prehistoric Sciences.—Prof. E. O. James (*Chairman*), Dr. D. B. Harden, O.B.E. (*Secretary*), Prof. C. F. C. Hawkes, F.B.A. **£10.**

To carry out research among the Ainu of Japan—Mrs. Brenda Seligman (*Chairman and Secretary*), Prof. Daryll Forde, Lord Raglan, Mr. Arthur Waley, C.B.E. **£50.**

To explore means for promoting and systematising the study of Ancient Field Systems—Prof. C. F. C. Hawkes, F.B.A. (*Chairman*), Mr. H. C. Bowen (*Secretary*), Mr. C. W. Phillips.

The Council wishes to report that the Geological Photographs Committee has now been wound up and that the sum of £176 15*s*. 5*d*., resulting from the profit on the sale of photographs, has been transferred to the Association's account. The Council have agreed that the photographs should remain in the Department of Geology, Imperial College of Science and Technology, where they can be referred to on application to Dr. W. S. Pitcher.

Leicester and Leicestershire Fund

35. The Council report that they have made a grant of £50 to Mr. P. R. Wells towards the cost of preparing his Ph.D. thesis from the Fund set up in 1933 for the purpose of helping, by scholarships or otherwise, students working for the advancement of science.

Biological Stations

36. The Council have agreed that the annual grants of £50 to the Biological Stations at Plymouth and Windermere should be renewed for 1958, and that the grant of £100 per annum to the Marine Station at Naples should also be renewed.

Resolutions and Recommendations

37. The Council have, at the request of the Section Committees, considered the question of the standing of contributors to the programmes of the Annual Meeting and have agreed that the general principle that speakers wishing to attend the whole Meeting should become members should be maintained, but that consideration might be given to special cases involving individual hardship.

Scientific Films

38. A programme of scientific films will be screened daily in the Students' Union of the University of Glasgow. The Council wish to record their gratitude for

the support given to them in this work by the Scientific Films Association and the British University Films Council and wish particularly to thank Mr. A. M. Hughes, Secretary of the Scientific Films Association, who has made all the arrangements for showing films at Glasgow. The Council are indebted also to the Council of the Royal Photographic Society, and in particular to the Officers of their Scientific and Technical Group for having, once again, agreed to be responsible for arranging a programme of research films.

Prizes

39. *Endeavour Essay Prize*, 1958.—The publishers of *Endeavour* offer once again prizes in an essay competition in connection with the Glasgow Meeting. The subjects for the competition are as follows: education for an age of science; rockets and satellites and their scientific significance; photography and cinematography in science; chemicals from petroleum; Darwinism today; and the measurement of time.

The names of the successful competitors were announced at Glasgow and they, together with the exhibitioners and selected students appointed to attend the Meeting, were received by the President and other Officers at a special reception at which the essay prizes were presented.

[First prize, C. J. Perrin, second prize, Miss Angela Glynn; third prize, J. C. Horrocks; prizes in the junior section, A. Orchard and A. Billson.]

40. *South Africa Medal.*—The Council are pleased to report that the South Africa Medal and Grant for 1957–58 has been awarded by the South African Association for the Advancement of Science to Dr. Margaret Levyns.

APPENDIX A

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

LECTURESHIPS FOR YOUNG SCIENTISTS

Conditions of Award

1. At their meeting on February 12, 1958, the Council of the Association decided to establish the following special Lectureships:

(*a*) 'Kelvin': Mathematics, Physics, Chemistry and Engineering.
(*b*) 'Darwin': Zoology, Botany, Physiology and Biochemistry, Geology, Agriculture and allied fields.
(*c*) 'Lister': Geography, Economics, Anthropology and Archaeology, Psychology, Education and Sociology.

2. The purpose of these Lectureships is to encourage the younger scientist to convey in non-specialist language to intelligent people, who are not experts, what he is doing and why, thus contributing to the Association's efforts to make natural science and the scientific method understood and accepted by the general public as part of daily life.

3. The selected lecturers should be scientists below the age of 35 years on August 31st of the year for which the appointment is made.

4. The three lectures should be delivered at the Annual Meeting and should be included in the programme of the appropriate Section in each case.

5. The Council invites the Committee of each Section of the Association (and others) to submit nominations for these Lectureships, in each case giving the reasons for the nomination and, in particular, their views on the ability of the person recommended to express himself intelligibly to non-specialist audiences and to present his subject in an attractive manner.

6. The Council will appoint a Committee to consider nominations received from the Sections and to submit their recommendations for the appointment by Council of a lecturer in each of the three categories to the Council for approval.

7. Each of the three lecturers appointed will receive an honorarium of 60 guineas and be accorded the financial privileges of a Recorder for the purpose of attending the Annual Meeting.

8. Each lecturer appointed will be required to meet a Panel appointed by the Council to discuss the content and presentation of his lecture and this Panel will be composed of three scientists, a representative of the Press (a science writer) and a representative of the B.B.C. The Panel will also consider any proposal made by the lecturer about the provision of visual material and, if they consider it necessary, will make a recommendation for a grant for this purpose.

9. It is a condition of the award that each lecturer appointed should agree to deliver his lecture after the Annual Meeting in two other centres, as decided by Council, for which he should be paid any necessary expenses incurred.

10. The Council agreed that the first appointments to these Lectureships should be made in time for the York Meeting in 1959 and invites Section Committees to make nominations not later than September 30, 1958.

APPENDIX B

SCIENCE IN SCHOOLS CONFERENCE

Royal Geographical Society, London

April 17 *and* 18, 1958

Thursday, April 17

10 a.m. OPENING CEREMONY

THE RT. HON. THE LORD HEYWORTH

FIRST SESSION

Chairman: SIR BEN LOCKSPEISER, K.C.B., F.R.S.

1. *The National Need*
   SIR SOLLY ZUCKERMAN, C.B., F.R.S.
   (Sands Cox Professor of Anatomy, University of Birmingham)

2. *Science as a Component of General Education*
   SIR ERIC JAMES
   (High Master, Manchester Grammar School)

3. *Scientific Education for Girls*
   MISS E. M. HUXSTEP
   (Head Mistress, County Grammar School for Girls, Cheltenham)

Discussion

12.30 p.m. LUNCHEON INTERVAL

2.30 p.m.

SECOND SESSION Science Teaching—The Present Position

Chairman: MR. F. L. ALLAN
(Head Master, Wallasey Grammar School, Past President, Incorporated Association of Head Masters)

(i) *The Supply of Science Teachers*
DR. A. W. BARTON
(Head Master, City of London School, member of National Advisory Council for the Supply and Training of Teachers)

(ii) *Accommodation and Equipment*
DR. H. F. BOULIND
(Department of Education, University of Cambridge, member of Science Masters' Association)

Discussion

Friday, April 18

10 a.m.

THIRD SESSION Meeting the Need

Chairman: MR. M. G. BENNETT
(General Treasurer, British Association for the Advancement of Science)

1. *The Supply of Science Teachers*

(i) *The Role of the Universities*
DAME KATHLEEN LONSDALE, D.B.E., F.R.S.
(Professor of Chemistry and Head of Department of Crystallography, University College, London)

(ii) *The Role of the Teachers' Training Colleges*
DR. D. R. CHESTERMAN
(Warden of Goldsmiths' College, member of Association of Teachers in Colleges and Departments of Education)

2. *The Provision of Facilities—What the Local Education Authorities can do*

(i) DR. J. W. F. HILL, C.B.E.
(President of the Council, Nottingham University, member of Lincoln City Council)

(ii) DR. B. E. LAWRENCE, C.B.E.
(Chief Education Officer, Essex County Council)

Discussion

12.30 p.m. LUNCHEON INTERVAL

2.30 p.m.

FOURTH SESSION
Chairman: SIR RAYMOND PRIESTLEY, M.C.

Discussion and Summing Up
THE RT. HON. THE LORD TEDDER, G.C.B.

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August 27 – September 3, 1958

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* (Dr. H. O. Bull acted as Recorder for the period of the Glasgow Meeting).

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GLASGOW MEETING
SECTIONAL TRANSACTIONS

Any references to publication supplied by authors will be found in the list below. References indicated by 'cf.' are to appropriate works quoted by the authors of papers, not to the papers themselves.

SECTION A

MATHEMATICS AND PHYSICS

Thursday, August 28

High-speed flight. (*See entry under Section G.*)

The physics of quanta:

Nature, **182**, No. 4643, pp. 1119–21.

Prof. P. I. Dee, F.R.S.—*The physics of quanta.*

It is appropriate that this analysis of the role and importance of the quantum hypothesis should take place in the centenary year of the birth of Max Planck. The development of the quantum concept will be traced and an account given of recent advances in our understanding of the interaction of radiation and matter.

Mr. J. M. Reid.—*The use of high-energy quanta in nuclear investigations.*

The paper will survey the results which have been obtained over the last few years from laboratories which have high-energy electron machines. Photonuclear and photomeson interactions will be discussed and a brief account given of some of the very recent experiments conducted with the Glasgow synchrotron.

Prof. J. C. Gunn.—*The non-conservation of parity.*

A clear explanation of the meaning of the reflection principle will be given and the significance of the recent experiments which necessitate the abandoning of the parity conservation for certain nuclear interactions will be explained and discussed.

Dr. J. G. Rutherglen.—*The techniques and uses of millimicrosecond measurements.*

The importance of very short time measurement in physics will be emphasised and an account given of the physical knowledge gained from experiments in nuclear interactions in which time intervals of a millimicrosecond (10^{-9} sec) and less have been measured.

Friday, August 29

Heat transfer. (*See entry under Section G.*)

Dr. R. W. Powell.—*Applications of a thermal comparator.*

A simple device is described which can be used for comparative non-destructive test measurements of factors affecting the heat flow through a small contacted area. Applications include sorting of materials, thermal conductivity determinations, assessment of surface finish, thickness of sheet materials or of surface deposits.

Dr. E. G. James.—*The preparation and properties of P-N junctions.*

P–N junctions in germanium and silicon can be prepared by either (*a*) doping during crystal pulling, (*b*) alloying or (*c*) diffusion. These methods are described and the electrical properties and possible applications of such junctions are discussed.

Dr. J. Shields.—*The design and performance of semi-conductor junction rectifiers.*

The factors influencing the physical design, fabrication and engineering performance of silicon and germanium rectifiers are discussed. These rectifiers have many interesting and important applications: for example, in the field of

electro-chemistry and traction. Typical performance of such diodes will be compared with other rectifiers.

To appear in *B.T.-H. Activ.*

Cf. 'Silicon *pn* junction diodes for power supply application', *Engineer*, p. 801 (June 1956); 'Silicon *pn* junction diodes', *Direct Current* (Sept. 1956); 'The elemental semiconductors—silicon and germanium', *Electrical Energy* (Oct., Nov., Dec. 1957); with D. J. Sandiford, 'Reverse current and carrier lifetime in silicon *pn* junctions': Report on Semiconductor Conference held at Ashborne Hill, Nr. Leamington, April, 1956; 'The avalanche breakdown voltage of hemispherical *pn* junctions', *J. Electronics & Control*, **4**, No. 1 (Jan. 1958); 'Avalanche breakdown voltage of narrow p^+/n^+ diodes', *J. Electronics & Control*, **4**, No. 1 (Jan. 1958).

Mr. G. King.—*P-N junctions and transistors.*

Transistor action and the assembly of systems of P-N junctions, to provide devices for electronic circuits for amplification, etc., and photoelectric conversion.

Crystal physics. (*See entry under Section B.*)

Monday, September 1

PRESIDENTIAL ADDRESS by Dr. T. E. Allibone, F.R.S., on *Some aspects of thermonuclear research.*

A review of experimental and theoretical work leading to the generation and control of high current discharges in hydrogen aimed at producing temperatures high enough for fusion to occur.

Mr. R. W. P. McWhirter.—*Experiments with 'Zeta'—a description of the methods used to determine the properties of plasma at thermonuclear temperatures.*

The lecture will start with a short description of Zeta. The experimental methods described will include: (*a*) measurement of the Doppler width of spectral lines; (*b*) magnetic probe measurements; (*c*) detection of neutrons and X-rays; (*d*) measurement of spectral line intensities.

Mr. B. S. Liley.—*Sceptre: theory and experiment.*

Experimental results obtained with Sceptre, a high-current stabilised pinched discharge, are presented. The possible origins of the neutrons observed and the heating mechanism of the gas are discussed, while the extension of such a device to the preparation of a power-producing reactor is considered.

Tuesday, September 2

Modern problems in friction and lubrication.

Nature, **182**, No. 4641, pp. 980–1.

Dr. F. P. Bowden, C.B.E., F.R.S.—*Introduction, and some problems in travelling at* 2,000 *m.p.h.*

This will be an introductory paper to the session on problems in friction and lubrication which confront us in the present age. It will go on to describe recent investigations on the friction and deformation of solids which are moving at very high speeds.

Cf. F. P. Bowden & J. H. Brunton, 'Damage to solids by liquid impact at supersonic speeds', *Nature*, **181**, 873–5.

Dr. D. Tabor.—*Rolling, skidding and sliding.*

When a hard ball *rolls* on rubber most of the resistance to rolling arises from deformation losses in the rubber. In *sliding* there is, in addition, the work of over-coming interfacial adhesion. If the surfaces are wet or greasy this may become very small. The friction is then determined primarily by the deformation losses in the rubber. Thus under skidding conditions the friction may be increased by selecting a rubber possessing high hysteresis losses.

To appear in *Engineering.*

Cf. J. A. Greenwood & D. Tabor, 'Friction of hard sliders on lubricated rubber: the importance of deformation losses', *Proc. phys. Soc. Lond.* **71**, 989 (1958).

Dr. C. G. Williams.—*Lubrication in the nuclear age.*

The advent of nuclear power stations has brought new problems in the field of lubrication. In particular, lubricants are required which will function in the presence of high-energy neutrons, electrons and gamma rays. This is a new

aspect, and work on the search for suitable radiation-resistant oils, greases or synthetic fluids is described.

To appear in *Engineering*.

Dr. F. T. Barwell.—*Newer aspects of fluid lubrication.*

Model demonstration of classical theory. Modern refinements, both experimental and theoretical. Static and dynamic air bearings. Problems imposed by higher speeds. High loads.

To appear in *Engineering*.

Cf. F. T. Barwell, *Lubrication of Bearings* (Butterworth).

Mr. J. F. Archard and Dr. W. Hirst.—*The wear of metals.*

Recent work shows that wear obeys definite rules and that the physical mechanisms of wear can be studied in detail. Some of the phenomena of wear are discussed.

To appear in *Engineering* and in *Scientific Lubrication* (Oct. 1958).

Cf. J. F. Archard, *J. appl. Phys.* **24**, 981 (1953); J. F. Archard & W. Hirst, *Proc. roy. Soc.* A **236**, 397 (1956); J. F. Archard & W. Hirst, *Proc. roy. Soc.* A **238**, 515 (1957); J. Dyson & W. Hirst, *Proc. roy. Soc.* B **67**, 309 (1954); W. Hirst & J. K. Lancaster, *J. appl. Phys.* **27**, 1057 (1956); W. Hirst, Instn Mech. Engrs Conference on Lubrication and Wear, Paper 66 (1957).

Wednesday, September 3

Microwave physics:

Nature, **182**, No. 4643, pp. 1121–3.

Dr. K. W. H. Stevens.—*The application of microwave physics to the study of the solid state.*

The application of war-time developments in microwaves is being increasingly applied to the study of the solid state, using, particularly, resonance methods. An account will be given of the main principles of the resonance technique and an assessment made of the results which have been obtained, and of future prospects.

Cf. K. W. H. Stevens & B. Bleaney, 'Paramagnetic resonance', *Rep. Progr. Phys.* **xvi**, 108 (1953).

Dr. D. J. E. Ingram.—*The technical applications of microwave physics.*

The study of solids in the microwave region is providing some very important information on their internal constitution and structure. These results can now be correlated with other physical and chemical properties and the microwave measurements can thus be used as a tool to study compounds of considerable practical importance.

Mr. I. M. Ross.—*Applications of atomic and molecular resonance phenomena to microwave technology.*

Atomic and molecular resonance phenomena are providing new methods of generating microwaves, with the advantage of high stability and the possibility of extension to still shorter wavelengths. They have also led to new methods of amplification of exceptionally low noise. Examples are described, with an outline of the physics underlying their behaviour.

SUB-SECTION A*

MATHEMATICS

Thursday, August 28

Prof. I. N. Sneddon.—*Mathematics in Glasgow in the eighteenth century.*

Friday, August 29

The use of electronic computers:

Dr. A. D. Booth.—*Prospects and probabilities in electronic data processing.*

A very brief survey of what has been achieved in the field of automatic digital computation will lead to a discussion of present and future needs in the scientific and economic spheres. The extent to which present techniques can

be extrapolated to meet these requirements will be examined and necessary future developments will be indicated.

Mr. E. A. Newman.—*The principles of information retrieval.*

Cf. E. A. Newman, 'An analysis of non-mathematical data-processing', *Symposium on Mechanization of Thought Processes*, N.P.L., November 1955. To be published by H.M.S.O.

Mr. K. B. Elbourne.—*The usefulness of digital computers in business problems.*

Mr. R. L. Michaelson.—*Five days in the life of a computer.*

Discussion.

A factual account of the use made of an electronic digital computer. The different applications are described with the emphasis on practice rather than theory.

Tuesday, September 2

The teaching of mathematics.

Nature, **182**, No. 4642, pp. 1064–5.

Mr. W. J. Langford.—*School mathematics in the twentieth century.*

The history of the Mathematical Association; Euclid's 'order' superseded; development of the co-ordinated subject 'mathematics' in grammar schools; the Jeffery report and 'alternative' syllabus. On this historical outline will be built an account of present-day methods of teaching and the scope of the work now attempted in schools.

Prof. H. Levy.—*Purpose and practice in mathematical teaching.*

The paper will examine how the selection of topics and the form of presentation and development depend on the purpose for which the subject is being studied.

Dr. E. A. Maxwell.—*Learning from mistakes.*

It is sometimes more dramatic to follow an error to its logical conclusion rather than merely to exhibit it. The conclusion '$\therefore 1=0$' may convince a pupil of his error more effectively than its immediate correction.

Cf. E. A. Maxwell, *Fallacies in Mathematics* (to be published by C.U.P.).

Prof. L. Rosenhead, C.B.E., F.R.S.—*The teaching of mathematics for the age of science and technology.*

The lecturer will discuss some of the problems which confront teachers of pure and applied mathematics resulting from the national policy to expand universities and colleges of technology and from the shortage in grammar schools of well-qualified teachers of mathematics and physics.

General discussion opened by Dr. B. E. Lawrence, C.B.E.

SECTION B
CHEMISTRY

Thursday, August 28

PRESIDENTIAL ADDRESS by Professor H. J. Emeléus, C.B.E., F.R.S., on *The chemistry of the transuranic elements.*

This address will review the chemical properties of the newly discovered transuranic elements and their significance both to the progress of inorganic chemistry and to the development of new techniques.

Dr. G. G. Freeman.—*Silicone polymers: an introduction to their properties.*

The preparation of silicone polymers will be briefly described. Applications of silicone fluids, resins and elastomers (rubbers) depend upon the following characteristics: constancy of properties over a wide range of temperature, water repellency, anti-adhesion, etc. These properties and typical applications will be illustrated by demonstrations.

Cf. G. G. Freeman, 'Silicones: an introduction to their chemistry and applications', *Plastics Monograph No. C.9* (Plastics Institute, 1955); 'The versatile silicones', *New Scientist*, pp. 309–12 (July 3, 1958).

Mr. N. L. Paddock.—*Phosphonitrilic halides: aromatics without carbon.*

The cyclic and linear compounds related to the inorganic polymeric series of phosphonitrilic chlorides show many features which suggest a hitherto

unrecognised type of aromaticity, the origin and consequences of which are discussed in this paper.

To appear in *Research*.

Cf. N. L. Paddock, 'A novel type of aromaticity', *Nature*, **181**, 1052 (1958); N. L. Paddock & H. T. Searle, *Advances in Inorganic Chemistry and Radiochemistry* (Academic Press).

Friday, August 29

The applications of crystallography to chemistry:

Nature, **182**, No. 4640, pp. 914–16.

Professor J. Monteath Robertson, F.R.S.—*Measurement of molecules by X-rays.*

An account will be given of recent advances in X-ray crystallography and its application to the study and measurement of the molecules with which organic chemistry deals. Very exact pictures of simple molecules can be made, and the method helps the chemist to discover the arrangement of atoms in complex molecules.

To appear in *Adv. of Science*, March 1959.

Mr. P. Pauling.—*A rebirth of inorganic crystallography.*

When atomic crystallography began, the structural analyses were done of those substances available in bottles on crystallographers' shelves, beginning with table salt, and as the technique developed, organic and biological substances became fashionable. Recent years have seen a renewed interest in more unstable man-made inorganic compounds.

Mr. H. M. Powell, F.R.S.—*How molecules fit together.*

Mutual attractions force molecules, when they form crystals, into arrangements as closely packed as their diverse shapes will allow. Similar or different shapes may adjoin, enclose, fit peg-in-the-hole, interpenetrate, or form key-fret patterns as complicated as any from China. Some of these will be shown and simplified.

Crystal physics:

Dame Kathleen Lonsdale, D.B.E., F.R.S.—*Man-made diamonds.*

X-ray diffraction and spectrographic analysis of diamonds made in the U.S.A. show that they contain nickel inclusions which are so similar in structure to diamond that they may well have been the agent causing crystallisation to occur in the desired form.

Dr. H. Judith Grenville-Wells.—*Diamonds in the sky.*

Diamonds are often found in nickel-iron meteorites. Early experimenters felt that meteorites held the key to diamond synthesis, but their hopes were not realised. Nevertheless, a study of the Canyon Diablo meteorite played a part in the successful synthesis of diamonds in the U.S.A.

Cf. Dame Kathleen Lonsdale & Dr. H. J. Grenville-Wells, 'X-ray study of laboratory-made diamonds', *Nature*, **181**, 758–9 (March 15, 1958).

Dr. I. M. Dawson and Dr. D. H. Watson.—*Molecules a million times larger than life.*

The high resolving power of the electron microscope has been used to study various protein molecules and crystals. In general, the results show how the individual molecules are arranged in the crystal lattice and in some favourable cases units of substructure within the molecule can be distinguished.

Substance of address to appear in first number of *Journal of Molecular Biology*. To appear in *Adv. of Science*, March 1959.

Dr. J. W. Menter and Dr. P. B. Hirsch.—*The imperfect crystal.*

The lattice of atoms or molecules of which a crystal is made is usually disturbed by imperfections. The most important of these, the dislocations, by their movement and interaction under stress largely determine the mechanical properties of a crystal. This paper describes two approaches to the direct study of dislocations using the electron microscope. The Tube Investments group (J. W. Menter, G. A. Bassett and D. W. Pashley) have obtained direct images of individual dislocations at very high magnifications where the crystal lattice itself is directly imaged and the lattice disturbance associated with the dislocation is seen. The Cavendish group (P. B. Hirsch, R. W. Horne and M. J. Whelan), working at lower magnifications, have obtained pictures of dislocation arrays in metals and have studied their movement and interaction by cine techniques (film to be shown).

Cf. J. W. Menter, 'The direct study by electron microscopy of crystal lattices and their imperfections', *Proc. roy. Soc.* A **236**, 119 (1956); D. W. Pashley, G. A.

Bassett & J. W. Menter, 'Observations of dislocations in metals by means of moiré patterns on electron micrographs', *Nature*, **179**, 752 (1957); G. A. Bassett & J. W. Menter, 'Electron microscopic observation of periodic structures below 10 Å', *Phil. Mag.* **2**, 1482 (1957); G. A. Bassett, J. W. Menter & D. W. Pashley, 'Moiré patterns on electron micrographs and their application to the study of dislocations in metals', *Proc. roy. Soc.* A **246**, 345 (1958); J. W. Menter, 'Seeing crystal lattices and dislocations', *Penguin Science News*, No. 43; J. W. Menter, 'The electron microscopy of crystal lattices', *Phil. Mag. Suppl.* **7**, 299 (1958); Hirsch, P. B., Horne, R. W. & Whelan, M. J., *Phil. Mag.* **1**, 677 (1956); Bollmann, W., *Phys. Rev.* **103**, 1588 (1956); Whelan, M. J. & Hirsch, P. B., *Phil. Mag.* **2**, 1121 (1957a); *Phil Mag.* **2**, 1303 (1957b); Whelan, M. J., Hirsch, P. B., Horne, R. W. & Bollmann, W., *Proc. roy. Soc.* A **240**, 524 (1957); Tomlinson, H.M., *Phil. Mag.* **3**, 867 (1958); Hirsch, P. B., Silcox, J., Smallmann, R. E. & Westmacott, K. H., *Phil. Mag.* **3**, 897 (1958).

Monday, September 1

Some recent trends in metallurgy:

Nature **182**, No. 4643, pp. 1123–5.

Sir Andrew McCance, F.R.S.—*Introduction.*

Professor R. Hay and Dr. P. T. Carter.—*Some recent applications of chemistry to metallurgical problems.*

Reference will be made to the relationship between chemistry and metallurgy. Because of the ever-increasing demand for purer metals problems associated with refining will be given prominence. Deoxidation, zone refining and vacuum melting will be discussed. The application of chemical principles to the problems of extraction processes will be considered.

Dr. H. M. Finniston and Dr. P. Murray.—*Newer metals in Industry.*

In the last ten years many metals hitherto classed as 'rare' have been developed for new applications in industry. Thus in atomic energy such metals as uranium, plutonium, thorium, beryllium, zirconium and niobium have had to be developed rapidly, and advances have also been made with other metals, such as titanium for aircraft applications and germanium and silicon for semi-conductors. The problems encountered and the results obtained in the field are surveyed.

Shortened version to appear in *Research.*

Dr. N. P. Inglis and Mr. J. B. Cotton.—*Corrosion behaviour of some of the newer metals.*

The paper sketches development of the newer metals now coming into commercial production and the corrosion behaviour of titanium, zirconium, beryllium, niobium and tantalum are contrasted. The dependence of corrosion resistance upon integrity of surface films is discussed and illustrated by detailed reference to the valuable anodic polarisation properties of titanium.

Cf. *Chem. & Ind.* (*Rev.*), pp. 68–9, 492–3 (1958).

Tuesday, September 2

Organic fluorine compounds—the taming of an element:

To appear in *Nature*; *Drug and Chemical Exports*, **19**, 22 (Oct. 1958).

Dr. J. C. Tatlow.—*Fluorocarbons: a new branch of organic chemistry.*

A new series of organic compounds has been discovered based on carbon and fluorine, paralleling orthodox organic compounds based on carbon and hydrogen. Many fluorocarbons and their derivatives possessing functional groups have now been made. They have many remarkable properties, including great chemical and thermal stability and non-inflammability.

Mr. H. R. Leech.—*Industrial advance of fluorine.*

The development of fluorine chemistry can really be traced to the marketing of anhydrous HF in the early 1930's. Four routes to fluorine compounds from anhydrous HF will be considered and the compounds now available on the market, made by these routes, will be reviewed.

Dr. B. C. Saunders.—*Physiological properties of toxic organic compounds containing fluorine.*

Classification of different types of toxic action caused by organic compounds containing fluorine. Chemical warfare agents. Anticholinesterase action. Peacetime uses in the investigation of enzyme systems. Applications as insecticides and in clinical medicine. Fluoroacetic acid and its biochemistry. Other compounds containing the C-F link.

Dr. John Campbell.—*Fluorine and dental decay: fifty years of research.*

In 1908, investigators reported that dental decay was low in areas where 'mottled teeth' were endemic, and that a water-borne element was suspect. The discovery of fluorine as the responsible factor, and subsequent researches, will be described.

Adv. of Science, December 1958.

SECTION C

GEOLOGY

Thursday, August 28

Professor T. N. George.—*The geology of the Glasgow district.*

Dr. A. G. MacGregor.—*Geological Survey work in the Glasgow region.*

Scottish Carboniferous 'Red Beds': a survey of recent work.

Mr. W. Mykura.

Substance of paper to be published in the *Geological Survey of Great Britain* under title of 'The replacement of coal by limestone and the reddening of coal measures in the Ayrshire coalfield'.

Mr. E. H. Francis.

Mr. G. I. Lumsden.

Mr. W. A. Read.

Cf. W. A. Read, 'The economic geology of the Stirling and Clackmannan coalfield, Scotland, area south of the River Forth', Coalfield Paper of the *Geol. Surv. Gt. Brit.*

Mr. W. Tulloch.

The red colour of most of the Scottish Carboniferous red beds, including the Barren Red or Upper Coal Measures, is thought to be due to oxidation which took place below a land-surface of late Carboniferous–early Permian times. Associated with it is the alteration of coal to carbonate now recognised not only in Ayrshire but also in Fife, Lanark, Clackmannan and Midlothian. The reddening affects rocks of widely differing horizons and in Ayrshire extends to a depth of at least 1,750 ft. below the Permian.

Other examples of reddening in Fife, Clackmannan and Midlothian seem to result from oxidation of intra-Carboniferous age and probably underlie minor unconformities. In Stirlingshire there is a case of coal partially altered to carbonate, which is not accompanied by reddening or caused by any known igneous intrusion.

Friday, August 29

Applied geophysics

Dr. M. H. P. Bott.—*The uplift of granite masses—a problem of isostasy.*

The uplift of granite masses, both during and after emplacement, is to be discussed in relation to the mass deficiencies which cause the associated negative gravity anomalies. It is suggested that an isostatic type of uplift in response to the mass deficiency frequently provides an adequate explanation.

Cf. M. H. P. Bott, 'A geophysical study of the granite problem', *Quart. J. geol. Soc. Lond.*, **112**, 45–67 (1956).

Mr. A. C. McLean.—*A gravity survey of Ayrshire.*

The results of a recent semi-detailed gravity survey of Ayrshire, plus detailed traverses across the Southern Upland Fault and the other major NE.–SW. faults of this part of the Midland Valley will be shown, and their geological significance discussed.

Dr. W. Bullerwell.—*Recent geophysical surveys by the Geological Survey.*

A brief account of some recent geophysical surveys designed to assist in the geological study of concealed structures, including ground, airborne and borehole geophysical surveys.

Dr. D. T. Germain-Jones.—*Geophysical exploration for oil in Great Britain.*

Geophysical surveys of various types have been conducted almost continuously over the past twenty years in the search for oil in Great Britain by the

British Petroleum Co. Ltd. A brief description of the more important results of these surveys will be given, with suitable illustrations.

Geology and oil

Nature, **182**, No. 4639, pp. 832–4.

Mr. F. E. Wellings.—*The contribution of the science of geology to the discovery and development of oilfields.*

Geology being earth science and petroleum a normal constituent of sedimentary rocks, geologists have played a leading part in the scientific side of the oil industry and, along with geophysicists and petroleum engineers, still do. The methods employed and the techniques evolved in locating and drilling wells, the analysis of reservoir rocks and the estimation of reserves have contributed greatly to the rapid expansion of the oil business.

Dr. A. H. Smout.—*Microfacies.*

Mr. D. R. Brown.—*Problems of geophysical prospecting for oil in the Middle East.*

Gravity and magnetic reconnaissance with seismic detailing. Logistic and equipment problems in remote areas. Prevalence of shallow limestone overlying lighter and lower velocity beds, salt flowage in cores of steeper folds on basinal plugs originate major technical difficulties.

Dr. J. Birks.—*Well logging.*

Well logging is concerned with measurements of:

(1) the borehole (diameter, depth, inclination);
(2) the fluids in the hole and in the rock (pressure, temperature, flow rate, electrical characteristics);
(3) the rock (formation dip, radioactivity, porosity, permeability, electrical characteristics).

Logging programmes differ for exploration and exploitation wells and correlation of data with measurements on cores yields quantitative information of reservoir fluid and rock properties.

Mr. N. L. Falcon.—*The advancement of geological science by oil exploration.*

Oil exploration throughout the world is providing a vast accumulation of data which cannot always be adequately studied from the academic standpoint immediately, but which is ultimately of great value to university workers. It follows that any distinction between oil geology and academic geology is artificial.

Monday, September 1

PRESIDENTIAL ADDRESS by Professor L. R. Wager, F.R.S., on *Beneath the Earth's Crust.*

Dr. H. I. Drever.—*The Picritic facies of the Shiant Isles Sill.*

Interpretation of the origin of this facies in terms of crystal accumulation in situ is invalidated by new data.

Mr. D. S. Weedon.—*Ultrabasic rocks in Skye.*

The main features of the Sgurr Dubh ultrabasic rocks will be described and comparison made with the layered ultrabasic rocks of Rhum. The possible relationship of the minor ultrabasic intrusions of Skye to the Sgurr Dubh mass will be discussed briefly.

Mr. W. J. Wadsworth.—*The harrisitic cumulites of Rhum.*

A discussion of the structural and textural features which indicate the relative importance of gravity settling and upward growth of olivine in the formation of the ultrabasic cumulites of S.W. Rhum.

Sir Edward Bailey, M.C., F.R.S.—*Mobilisation in Ireland and sinking olivines in Greenland.*

(1) At Carlingford dolerite magma has remelted granophyre rock, and before completing its own crystallisation has been veined and chilled by the remelt.
(2) At Ubekendt Ejlund picritic dolerite, partially crystallised with gravitational differentiation, has been intruded to give a sill with olivine-rich middle.

Liverpool & Manchester geol. J., **III** (1958).

Cf. E. B. Bailey & W. J. McCallien, 'Composite minor intrusions and the Slieve Gullion complex, Ireland', *Liverpool & Manchester geol. J.* **I**, 466–501 (1956).

Tuesday, September 2

Session A

Aspects of Lower Carboniferous palaeontology:

Dr. R. H. Cummings.—*Sequence of foraminiferal assemblages in the Lower Carboniferous.*

The stratigraphical value of the sequence of Lower Carboniferous foraminiferal assemblages will be assessed in relation to the morphogeny of representative groups, the control by ecological factors, and the effects of diagenesis in the sediments.

Dr. Grace N. Dunlop.—*Shell development in* Spirifer trigonalis.

The study of the intimate structure of the shell of this spiriferid reveals the presence of internal growth lines. These growth lines provide a means of reconstructing the development of such structures as the dental plates and also give an indication of the mode of shell growth.

Mr. R. Goldring.—*Tournaisian Trilobites.*

Session B

Highland Schists:

Mr. D. M. Ramsay.—*Deformation studies in the Carn Mairg Quartzite of Glen Lyon.*

The structures occurring within uniform and gritty Carn Mairg Quartzite from different tectonic environments are described. A comparison is made between the grain fabric patterns of grits and uniform quartzite and differences in the movement picture of individual pebbles within grits are discussed.

Dr. D. R. Bowes.—*The Garnet Isograd in the Braes of Balquhidder.*

An account of the distribution of index metamorphic minerals in the Dalradian schists and of their development in relation to periods of Caledonian tectonic activity.

Cf. D. R. Bowes and K. A. Jones, 1958, 'Sedimentary Features and Tectonics in the Dalradian of Western Perthshire', *Trans., Edinburgh Geol. Soc.*, **17**, Part 2.

Dr. N. Rast and Dr. A. J. Smith.—*Succession and the sedimentary facies in the Dalradian rocks of Western Scotland.*

The sedimentary successions of the Iltay Nappe and the Ballapel Foundation are contrasted. Numerous sedimentary structures including current bedding, graded bedding, slumps, etc., are used to determine the conditions of deposition of diverse sedimentary facies and the possible sources of their derivation.

Mr. G. S. Johnstone.—*On the occurrence of 'slides' in Scottish hydro-electric tunnels.*

Several Scottish hydro-electric tunnels traverse ground in which major slides are thought to occur. Features which may represent these slides have been observed in several tunnels in positions where the slides were expected to occur. The significance of these features will be discussed.

Wednesday, September 3

Miscellaneous original papers:

Mr. J. H. Ashford.—*The dioritic rocks of Glen Dubh, Arran.*

An account of the dioritic rocks associated with the gabbro and microgranite of the eastern parts of the Central Complex of Arran.

Dr. W. E. Tremlett.—*The Pre-Cambrian rocks of southern Co. Wicklow (Ireland).*

Structural evidence of the Pre-Cambrian age of the Bray Series and an apparently underlying sedimentary series in S.E. Ireland.

To appear as 'The Pre-Cambrian Rocks of Southern Co. Wicklow (Ireland), Jan./Feb., 1959 issue of *Geol. Mag.*, **xcvi**, Part 1.

Dr. A. Lamont.—*Pliocene Platforms and Incised Meanders.*

Evaluation of Robert Chambers' work on Eustatic Theory. Recognition of Platforms by means of River Capture phenomena (Tweed at Peebles; N. Esk at Carlops. Ancient Knickpoints indicated at downstream end of Incised Meanders.

Mr. J. Tuson.—*A geophysical investigation of the Tertiary Volcanic Centres of Scotland.*

The large positive Bouguer anomalies found over the Tertiary Volcanic Centres are interpreted in terms of columns of basic rock extending into the

intermediate layer. The form of the basic intrusions and of the associated granites are described and the petrogenetic implications discussed.

Mr. A. L. Harris.—*Some aspects of evolution of quartz girdles.*

The evolution of quartz girdles is traced by reference to multiple stages of deformation identified in the Central Highlands of Scotland. New methods of petrofabric investigations are described.

SECTION D

ZOOLOGY

Thursday, August 28

PRESIDENTIAL ADDRESS by Dr. A. S. Parkes, C.B.E., F.R.S., on *Some biological effects of low temperatures.*

Life at low temperatures.

Nature, **182**, No. 4640, pp. 911–13; to appear in *Adv. of Science*, 1959.

Dr. K. Mellanby, C.B.E.—*The acclimatisation of insects to low temperatures.*

Insects are immobilised and killed by low temperatures. The same species become less or more resistant to low temperatures after exposure to warm or cool conditions. The ways in which insects become acclimatised will be discussed.

Dr. J. W. Kanwisher.—*Freezing problems of marine life.*

Extensive freezing of shore life results from tidal exposure to low winter air temperatures. The resulting severe conditions in the tissues are a strong selective factor on the winter shore. Arctic fishes escape freezing by either doubling the osmotic concentration of their blood or by remaining permanently supercooled.

Dr. C. Polge.—*The freezing and storage of sperm.*

Damage caused to sperm by freezing and thawing may be overcome by adding various protective agents to the semen. Variations in the resistance of sperm of different animals to freezing will be discussed in relation to long-term preservation of semen at very low temperatures for use in artificial insemination.

Dr. D. W. H. Barnes.—*Treatment of lethally irradiated mice.*

Mice can be protected after lethal irradiation by injection of cells of the red bone marrow which, it has been shown recently, survive as a graft. Before use the marrow can be stored at low temperatures under certain conditions and its continued survival traced in the irradiated recipient.

Cf. D. W. H. Barnes & J. F. Loutit, *J. nat. Cancer Inst.* **15**, No. 4, p. 901 (1955); C. E. Ford, J. C. Hamerton, D. W. H. Barnes & J. F. Loutit, *Advances in Radiobiology*, ed. G. C. de Hevesy, A. G. Forssberg & J. D. Abbatt (Oliver & Boyd, 1957).

Dr. Audrey U. Smith.—*Resuscitation of frozen mammals.*

Heart-beats and breathing stop when adult non-hibernating mammals are cooled below about 20°C. Although they appear to be dead, some can be revived after an hour of cardiac and respiratory arrest and after partial freezing. Isolated organs have recovered function after freezing for longer periods at much lower temperatures. Future possibilities will be discussed.

Friday, August 29

Darwin and anthropology. (*See entry under Section H.*)

Progress in microscopy.

Dr. E. J. Ambrose.—*A surface contact microscope for studying the movements of living cells.*

Active movements of tissue cells are now known to be of great importance in development, in normal wound healing and in cancerous growth. With the new technique of surface contact microscopy, the mechanism of these movements on surfaces may be studied directly on living cells; a short film will be shown to illustrate the method.

Dr. A. J. Hale.—*Cell weights and measures.*

With the interference microscope it is possible to 'weigh' extremely small objects and to measure their thickness accurately. The principle of the method

and its application will be presented. The importance of this 'microscopical balance' in cellular research will be discussed.

Cf. A. J. Hale, *The Interference Microscope in Biological Research* (E. & S. Livingstone).

Dr. H. F. Steedman.—*The cutting of sections.*

A very brief historical account of the media used for the cutting of tissue sections for histology, an explanation of why such media are necessary, and a survey of the types which are available today.

Prof. G. M. Wyburn and Dr. A. D. Hally.—*Biological fabrics.*

An account of the value of electron microscopy in making possible the direct observation of the molecular patterns which characterise cells and tissues.

Extended form to appear in *Research*, Oct. 1958.

Prof. C. M. Yonge, C.B.E., F.R.S.—*Form and biology of coral reefs.*

Coral reefs are marine communities characteristic of shallow tropical waters and they therefore lie within the Trade Wind belt. Their form, especially that of barrier reefs and atolls, with notable differences between exposed and sheltered surfaces, represents interaction between the biological forces of growth and the physical action of wind and sea.

Dr. J. W. L. Beament.—*New information on the waterproofing of insects.*

Insects could not survive without their very waterproof skins; the nature of the waterproofing process has caused some controversy. New techniques (which are also demonstrated) have shown earlier measurements of waterproofing to be misleading. They suggest a mechanism whereby a minutely thin layer of wax can yet be remarkably waterproof.

J. exp. Biol. (Sept. 1958).
Cf. *J. exp. Biol.* **32**, 514–38 (1955); *Discovery*, p. 268 (July 1958).
To appear in *The New Scientist*.

Prof. G. E. H. Foxon.—*Recent investigations on the circulation in Amphibia and Reptilia.*

The use of such methods as cinematography, cineradiology and blood-gas analysis has enabled the circulatory arrangements in lower vertebrates to be worked out in some detail in recent years. The results of such investigations will be reviewed.

Monday, September 1

The nature and genetical control of resistance in living organisms. (*See entry under Section K.*)

Salt and water balance in animal life. (*See entry under Section I.*)

Dr. J. Shaw.—*Sodium balance in some decapod Crustacea.*

Dr. R. Morris.—*Aspects of migration in lampreys.*

The river lamprey (*Lampetra fluviatilis*) undergoes a spawning migration from sea water or brackish water into European rivers. An account will be given of some of the changes which take place in the mechanism of salt and water balance to enable the animal to live in such diverse environments.

Cf. R. Morris, 'The osmoregulatory ability of the lampern (*Lampetra fluviatilis* L.) in sea water during the course of its spawning migration', *J. exp. Biol.* **33**, 235–48 (1956); R. Morris, 'Some aspects of the structure and cytology of the gills of *Lampetra fluviatilis*', *Quart. J. micr. Sci.* **98**, 473–85 (1957); R. Morris, 'The mechanism of marine osmoregulation in the lampern (*Lampetra fluviatilis* L.) and the causes of its breakdown during the spawning migration', *J. exp. Biol.* (1958).

Dr. J. D. Robertson.—*The origin of vertebrates—marine or fresh-water?*

Studies on the salt and water balance of aquatic vertebrates and other chordates are used as evidence bearing on the question of the marine or fresh-water origin of vertebrates, a question which cannot be decided by palaeontological data alone.

Cf. J. D. Robertson, *Biol. Rev.* **32**, 156–87 (1957).

Zoological Films.

Young budgerigars (presented by Sister Marie Josephine). A coloured film showing stages in development from the egg to the age of four weeks.

Breeding periodicity and related problems of two vertebrate animals in equatorial Borneo (presented with a commentary by Mr. Tom Harrisson). A talk, illustrated by films, of Edible Turtles and Edible Nest Swiftlets; material will be included from a film which has recently won the Grand Prix at the Cannes Film Festival.

Cf. Sister Marie Josephine, S.M.D., *Budgerigars*, published by Universities Federation for Animal Welfare (Aug. 1958).

Tuesday, September 2

The work of the Freshwater Biological Association.

Prof. W. H. Pearsall, F.R.S.—*The history of the Freshwater Biological Association.*

Dr. C. H. Mortimer, F.R.S.—*The physics and chemistry of lakes.*

An account of the contributions to the above subject by members of the staff of the Freshwater Biological Association, illustrated by slides and film.

Dr. J. W. G. Lund.—*Investigations on the algae of Windermere.*

The history of algal investigations on Windermere and other lakes in the district. The present state of knowledge of the causes of algal periodicity. Problems for the future and economic aspects.

Mr. E. D. Le Cren.—*Experiments with fish populations in Windermere.*

Investigations into numbers, growth, food, survival and angling of the fish species in Windermere can provide estimates of the total amounts of fish produced in the lake. An experimental reduction in the numbers of perch and pike has helped to show some of the interrelationships between the species.

Aspects of the evolution of form and function in molluscs:

Nature, **182**, No. 4641, pp. 996–8.

Prof. C. M. Yonge, C.B.E., F.R.S.—*Form and evolution in the Mollusca.*

The numerous fascinating problems of molluscan form and evolution can only adequately be presented in terms of conflicting growth axes of the body on the one hand and of the mantle shell on the other, the former being bilaterally symmetrical and the latter bi-radially symmetrical. General implications of this statement are briefly considered.

Cf. C. M. Yonge, 'The protobranchiate Mollusca: a functional interpretation of their structure and evolution', *Phil. Trans.* B **230**, 79–147 (1939); C. M. Yonge, 'The pallial organs in the aspidobranch Gastropoda and their evolution throughout the Mollusca'. *Phil. Trans.* B **232**, 443–518 (1947); C. M. Yonge, 'Form and habit in *Pinna carnea* Gmelin', *Phil Trans.* B **237**, 335–74 (1953); C. M. Yonge, 'The monomyarian condition in the Lamellibranchia', *Trans. roy. Soc. Edinb.* **62**, 443–78 (1953); C. M. Yonge, 'Mantle fusion in the Lamellibranchia', *Pubbl. Staz. zool. Napoli*, **29**, 151–71 (1957).

Mr. G. Owen.—*Form and function in lamellibranchs.*

Growth and form in the Bivalvia can be represented satisfactorily when the two valves together with the ligament are considered as a unit (i.e. parts of one structure—the shell). Changes in the growth gradients around the mantle margin affect the form of the shell and this can be analysed with reference to a demarcation line. The correlation between form and habit will be discussed.

G. Owen, 'The shell in the Lamellibranchia', *Quart. J. micr. Sci.* **94**, 57–70 (1953); G. Owen, 'Observations on the Solenacea with reasons for excluding the family Glaucomyidae', *Phil. Trans.* B (1958); G. Owen, 'Shell form, pallial attachment and the ligament in the Bivalvia', *Proc. zool. Soc. Lond.* (1958); G. Owen, E. R. Trueman & C. M. Yonge, 'The ligament in the Lamellibranchia', *Nature*, **171**, 73–5 (1953); C. M. Yonge, 'Studies on Pacific Coast mollusks. IV. Observations on *Siliqua patula* Dixon and on evolution within the Solenidae', *Univ. Calif. Publ. Zool.* **55**, 421–38 (1952).

Dr. G. E. Beedham.—*Composition of the lamellibranch shell.*

The composition of the non-calcareous material (conchiolin) in the shell is described. The concept that the outer and inner layers of the valves and of the ligament represent local modifications of the same two layers of the lamellibranch shell is examined by comparing the chemical properties of their conchiolin components.

Cf. G. E. Beedham, 'Properties of the non-calcareous material in the shell of *Anodonta cygnea*', *Nature*, **174**, 750 (1954); G. E. Beedham, 'Observations on the mantle of the Lamellibranchia', *Quart. J. micr. Sci.* **99**, 181–97 (1958); G. E. Beedham, 'Observations on the non-calcareous component of the shell of the Lamellibranchia', *Quart. J. micr. Sci.* (1958); G. Owen, E. R. Trueman, & C. M. Yonge, 'The ligament in the Lamellibranchia', *Nature*, **171**, 73–5 (1953).

Dr. W. D. Russell Hunter.—*Evolution of Gastropoda in freshwaters.*

Freshwater snails include both gill-breathers of marine origin and pulmonates, the latter showing the progressive readaptation to aquatic life of an air-breathing, gill-less stock. Variation occurs in (*a*) functioning of respiratory organs and (*b*) life-cycle and fecundity. The discontinuity in space and the impermanence in time of most fresh waters have been important factors in the evolution of these animals.

Cf. W. Russell Hunter, 'On migrations of *Lymnaea peregra* (Müller) on the shores of Loch Lomond', *Proc. roy. Soc. Edinb.* B **65**, 84–105 (1953); W. Russell Hunter, 'On the growth of the freshwater limpet, *Ancylus fluviatilis* Müller', *Proc. zool. Soc. Lond.* **123**, 623–36 (1953); W. Russell Hunter, 'The condition of the mantle cavity in two pulmonate snails living in Loch Lomond', *Proc. roy. Soc. Edinb.* B **65**, 143–65 (1953); W. Russell Hunter, 'Studies on freshwater snails at Loch Lomond', *Glasg. Univ. Publ., Stud. Loch Lomond*, **1**, 56–95 (1957); W. Russell Hunter & T. Warwick, 'Records of *Potamopyrgus jenkinsi* (Smith) in Scottish fresh waters over fifty years (1906–56)', *Proc. roy. Soc. Edinb.* B **66**, 360–73 (1957).

Mr. A. E. Henderson.—*Some adaptations of freshwater snails.*

The paper will deal with the ways in which freshwater snails use the air-filled mantle cavity which they have inherited from their air-breathing ancestors, and the possible ways in which such modifications may influence the distribution of the animals in nature.

Zoological Films.

New microscopic filming methods, presented by Dr. E. J. Ambrose.

SECTION E

GEOGRAPHY

Thursday, August 28

The Glasgow region:

Professor Ronald Miller.—*The Glasgow region.*

An outline geography of the Glasgow region with some introduction to the Section E excursions.

Mr. H. A. Moisley.—*The River Clyde and its part in the industrial and commercial development of Glasgow.*

Mr. D. R. Diamond.—*The urban morphology of the Glasgow region.*

A discussion of the Clydeside conurbation with reference to some features of its growth and present functions. The social and economic consequences and the present planning problems which arise from the urban structure will be indicated.

Friday, August 29

PRESIDENTIAL ADDRESS by Professor E. Estyn Evans on *The Atlantic ends of Europe.*

Mr. D. Justin Schove.—*Tree-rings, climatic chronology and historical geography.*

Tree-ring studies link up with the new evidence for climatic chronology based on palaeomagnetism, O_{18} and C_{14}. For historical times, tree-ring analysis can now be used to date oak in Roman and medieval England and pine or spruce in Scandinavia, and some inferences about rainfall and summer temperature can be made. The climatic fluctuations indicated by tree-ring and other evidence are beginning to tie in with the known economic fluctuations in Scotland and some climatically marginal areas.

Cf. D. J. Schove & A. W. C. Lowther, 'Tree-rings and medieval archaeology', *Medieval Archaeology*, London, I (1958); D. J. Schove, R. Nairn & N. Opdyke, 'The climatic geography of the Permian', *Geogr. Ann., Stockh.* (1958–9); *Quart. J. R. Met. Soc.* (1959–60); *J. Brit. Astr. Ass.* (1959); 'The Spectrum of Time' (in progress).

Dr. Karl A. Sinnhuber.—*The primeval landscape of Middle Europe: Gradmann's steppe-heath theory re-examined.*

Robert Gradmann's principal contribution to historical geography was the establishment of the importance of the primeval landscape. English critics have failed to take account of his later work; the paper aims to fill this gap and to re-examine Gradmann's thought in the light of recent research.

Mr. D. N. McMaster.—*Changing regional advantages in the Bukoba district of Tanganyika Territory* (read by Mr. V. Ford).

Mr. H. P. White.—*The ports of West Africa—some geographical considerations.*

The results of physical conditions and operating techniques on the development of West African ports.

Monday, September 1

Water resources and water needs in Scotland:

Dr. R. Maclagan Gorrie.—*The need for river-flow studies.*

An introduction to the symposium.

Mr. P. O. Wolf.—*Measuring river flow and estimating floods.*

A survey of the techniques and devices used for river-flow measurement in the British Isles and of some methods by which past and expected future floods may be estimated, with special reference to some of Capt. W. N. McClean's work.

Mr. F. H. W. Green.—*Evaporation and land use in water conservation studies.*

The value of the concepts of potential evaporation and of potential moisture deficit is discussed, and illustrated by current observations in Scotland. Practical application of these concepts involves consideration of the static factors of geology and topography, and the dynamic factors of land use and soils.

Mr. P. L. Aitken.—*Hydro-electric development in Scotland.*

The stage reached in the utilisation of water resources in Scotland for the generation of electricity and a brief assessment of potential hydro-electric development in the Highlands.

Mr. L. B. Aitken.—*Industry in relation to water supply.*

Professor A. Stevens.—*Geography in the medieval Scottish universities.*

Mr. F. V. Emery.—*A 'Description of Scotland' prior to the 'Statistical Accounts'.*

Students of Scotland and Scottish life have used the *Statistical Accounts* since they first appeared in the 1790's. This paper outlines the several schemes for a geographical survey of Scotland that foreshadowed the *Statistical Accounts* in the seventeenth and early eighteenth centuries.

Dr. Arthur Geddes.—*Scotland's 'Statistical Accounts' of Parish, County and Nation: c. 1790–1824 and 1836–1840.*

Sinclair's national volume formed the third storey of his 'pyramid of parishes, counties and nation'. Sinclair's questionnaire to rural parish ministers (each on his glebe) brought penetrating essays on 'the veritable revolution' they witnessed. Their findings, regional, rural and urban, are compared with those of 1836. Methods for use and application will be outlined.

Tuesday, September 2

Rural settlement.

To appear in *Adv. of Science*, 1959.

Professor H. J. Fleure, F.R.S.—*Chairman's Introduction.*

Dr. H. Fairhurst.—*The evolution of settlement in Western Scotland.*

Dr. V. B. Proudfoot.—*Clachans in Ireland.*

Evidence for clustered settlements in Ireland from the Dark Ages to the nineteenth century—a review of progress in settlement studies since Evans's classic paper on the subject in *Geography*, 1939.

To appear in *Gwerin.*

Mr. Glanville R. J. Jones.—*Rural settlements in Wales.*

The prevalence in Wales of scattered homesteads, essentially an expression of the breakdown of medieval clan tenure, obscures the fact that clan tenure

itself was preceded by an older tenurial system, characterised by a close grouping of homesteads into hamlets, and exhibiting close parallels with other areas of Britain.

Dr. W. Ravenhill.—*The Celtic and Early English settlement of Cornwall and Devon.*

The settlement of Cornwall and Devon between Roman and Norman times presents many problems; to assist in a solution of some of these, analyses of the kinds of sites occupied by Celtic and English peoples are compared.

Cf. 'The settlement of Devon in the Dark Ages', *Trans. Devonshire Ass.* LXXXVI, 63–74 (1954); 'The settlement of Cornwall during the Celtic period', *Geography*, XL, 237–48 (1955).

Wednesday, September 3

Mr. B. Fullerton.—*The pattern of 'service' industries in North-east England.*

An analysis of the distribution of people employed in transport, distribution, professional services and other 'service' industries as recorded in the 1951 Census. Some characteristic distribution patterns. The value and limitations of the data in the study of regional economic distributions.

Dr. R. H. Osborne and Dr. R. Jones.—*The geographical distribution of professional persons: with special reference to the place-attitudes of intending teachers in Scotland.* (To be read by Dr. Jones.)

Geographical variations in the distribution of persons in certain professions, and possible factors which may be responsible; followed by an account of a survey of place-attitudes expressed by intending teachers in Scotland, the results being then compared with the location of their first employment.

Mr. Leslie Symons.—*Kintyre: a Highland exception.*

A survey of the causes of the success of farming and efficiency of land utilisation in Kintyre, resulting in a degree of economic stability greater than usual in the Highlands today. Emphasis will be placed on the pattern of land ownership and the size of farm.

Miss Margaret Storrie.—*Islay: a Hebridean exception.*

Islay contrasts strongly with the Outer and, less strongly, with the other Inner Hebrides. Its twofold aspect of large farms and non-agricultural villages is quite different from that of the other Hebrides with their small scattered holdings and infrequent port villages. Islay has distinctive types of land utilisation, settlement, occupation and population structures.

SECTION F

ECONOMICS

Thursday, August 28

Mr. Aubrey Silberston.—*Competition and monopoly in the motor industry.*

The paper will be concerned with competition between car manufacturers. Reference will be made to the situation in the United States. There will be a discussion of competition between suppliers to the motor industry and of the relationship between these suppliers and motor manufacturers, and also of competition in the retail trade.

Cf. *The Structure of British Industry* (ed. Duncan Burn), Chap. 10 (Cambridge, 1958); G. Maxcy & A. Silberston, *The Motor Industry* (Allen & Unwin).

Mr. J. Maitland.—*Methods of assessing the effectiveness of an advertising campaign.*

An account of the results of certain investigations into methods of assessing the effectiveness of an advertising campaign; the paper also contains a note on the possible applications of operational research techniques in advertising.

To appear in *Adv. of Science*, 1959.

Mr. John Wiseman.—*The economics of education in Britain.*

A discussion of the principles which should govern the methods used to provide education and the volume of the community's resources devoted to such provision. A commentary on the present British system and possible changes therein in the light of these principles.

Friday, August 29

PRESIDENTIAL ADDRESS by Prof. A. J. Brown on *Inflation and the British economy.*

Monday, September 1

Mr. Ronald J. Brech.—*Economics in business.*

Economics can make a substantial contribution to the efficiency of business operations, first by providing an economic radar system to give forewarning of changes in the economic climate; secondly as a tool of management to ensure that right decisions are taken, and thirdly by providing information about the long-term future to facilitate more rational planning.

Mr. R. M. Lodge.—*Choice and valuation in industrial research.*

Too many research topics arise; a selection has to be made. Those projects which are undertaken have to be watched; how far and how fast should they be pursued? Research results need to be assessed. These quasi-economic activities form an important part of the duties of a scientist in charge of an industrial research organisation.

To appear in *The Electrical Times* and *The Economist; Adv. of Science*, Dec. 1958.

Cf. *Report of Proceedings of D.S.I.R. Working Conference on Research and Industrial Productivity*, Nov. 1954.

Tuesday, September 2

Mr. G. F. Rainnie.—*Competition in the woollen and worsted industry.*

A brief description and explanation of the differences in market structures and producers' behaviour in an industry commonly held to be 'intensely competitive'.

Miss Audrey G. Donnithorne.—*The economic background to the innovations in the rubber manufacturing industry in Britain.*

The economic background to innovations in the British rubber industry in the twentieth century. Discussion centres on the relation between the structure of the industry and new developments in manufactures, in rubber compounding and in the use of synthetic rubbers.

Cf. Audrey G. Donnithorne, *The British Rubber Manufacturing Industry: an Economic Study* (Gerald Duckworth & Co. Ltd., 1958 or 1959).

Dr. F. P. G. Whitaker.—*The teaching of management subjects in British Universities.*

Cf. *Technology*, p. 194 (Sept. 1958).

SECTION G

ENGINEERING

Thursday, August 28

Session A

High-speed flight.

Nature, **182**, No. 4637, pp. 695–6.

Professor W. J. Duncan, C.B.E., F.R.S.—*Introduction.*

Engineering, p. 278 (Aug. 29, 1958).

Mr. L. F. Nicholson.—*Aerodynamic aspects of high-speed flight.*

The impact of current aerodynamic thinking on flight at speeds ranging from the speed of sound to satellite speeds, is briefly reviewed. Aerodynamic contributions to problems of efficient supersonic cruising flight and to the new problems of speeds associated with long range ballistic flight are discussed.

Mr. E. C. Cornford.—*General aspects of travel at very high speeds with special reference to rockets and satellites.*

The performance and guidance and control requirements of long-range rockets and earth satellites are discussed, together with some of the problems which must be overcome in order to meet them.

Engineering (Aug. 29, 1958).

Session B

Mr. J. Walker.—*The control of nuclear reactors.*

Points discussed include: the choice of control variable; the balance between inherent and controlled reactivity changes; the range of neutron flux measurement and the siting of detectors; other instruments; and reactor protection circuits.

Cf. J. Walker & R. J. Cox, *J. Brit. Nuclear Energy Conf.* **1**, 106 (1956).

Dr. D. Taylor.—*Special instrumentation problems associated with nuclear power stations.*

The paper discusses a number of special instrumentation problems, including the measurement of flux distributions and the detection of burnt fuel elements.

Engineering (Oct. 1958).

Mr. G. J. R. MacLusky.—*Analogue computers and transfer function analysers, and their use in nuclear reactor studies.*

The principles of analogue computers are briefly described and their application to predict the kinetic behaviour of projected nuclear reactors is discussed. For measurements on an actual reactor system a transfer function analyser can be used, and its advantage in rejecting interfering signals is explained.

Friday, August 29

PRESIDENTIAL ADDRESS by Professor O. A. Saunders, F.R.S., on *Heat and the Engineer*.

Session A

Mr. J. M. Miller and Mr. G. F. S. Reising.—*Experimental determination of heat transfer and pressure loss with gas flow across banks of tubes.*

An extensive programme of testing heat transfer and pressure loss characteristics of both plain and finned tube banks is being undertaken at the Research Laboratories of Babcock & Wilcox Ltd. This paper describes the various rigs used in the heat transfer investigations and discusses the experimental procedure adopted. Several auxiliary investigations are also briefly reviewed.

To appear in *Engineering* and an abstract in the *Electrical Times*.

Session B

Mr. R. G. Voysey.—*The storage of energy.*

The paper surveys existing methods of storage of energy, indicating how much the application of these depends on special circumstance. It is shown that the internal-combustion engine running on special liquid fuels has reduced the need for developing a greater number of artificial means of storing energy for transport and transportable power, but that the economics of nuclear energy may encourage a review of pumped water and compressed-air storage for assisting the economics of electrical supply.

To appear in *Engineering*.

Monday, September 1

Water resources and water needs in Scotland. (*See entry under Section E, Geography.*)

Session A

Mr. J. Edwards.—*Nuclear propulsion.*

A survey of the prospects of nuclear power for propulsion purposes.

Professor J. F. C. Conn.—*Developments in naval architecture.*

A review of progress in our knowledge of the resistance, propulsion, motion, vibration and strength of ships.

To appear in *Engineering*.

Session B

Papers by young engineers:

Mr. C. P. Wroth.—*The behaviour of soils during shear.*

Results of shear tests on soils have been plotted three-dimensionally in terms of the normal stress, the voids ratio and the shear stress. The soil reaches

a condition in which it can continue to be deformed without any change of these three variables; and the point defined by these three fixed values lies on a unique line in this space.

Mr. A. J. Taylor-Russell.—*The aerodynamics of wakes.*

The wake of a bluff body which is placed in a steady flow of air is found to oscillate with a frequency nearly proportional to the speed of the air. A new explanation of this phenomenon will be discussed and compared with the usually accepted 'Karman Vortex Street'.

Mr. P. Strange.—*Vector Loci.*

General remarks on vector loci with time independent and time dependent parameters. Examples of both classes of loci. Synthesis of time dependent networks to give a specific locus.

Dr. S. Forbes Pearson.—*The measurement of losses in small refrigeration compressors.*

The paper describes a new method of analysing compressor performance. The method depends on the use of an electrical instrument measuring the instantaneous gas velocity in the inlet port of the compressor. The method can also be applied to reciprocating engines at high speed.

To appear in *Engineering*.

Tuesday, September 2

Session A

Modern problems in friction and lubrication. (*See entry under Section A.*)

Session B

The use of radio waves for position-finding and navigation:

Nature, **182**, No. 4641, pp. 978–80.

Dr. R. L. Smith-Rose, C.B.E.—*The general problems of radio position-finding.*

Several methods are in use for finding the position of a given point by radio techniques, and these are applied to sea and air navigation and to land survey work.

Some methods are based on the directional properties of aerial systems, while others rely on the speed of radio waves.

Engineering, **186**, 313 (Sept. 5, 1958).

Dr. B. G. Pressey.—*Marine radio navigational aids.*

A discussion of the problems of marine navigation and a description of radio position-fixing systems using shore-based transmitters and of the use of radar both on board ship for navigation and collision avoidance and also on shore for harbour and waterway control.

Mr. Caradoc Williams.—*The special problems of radio aids to aeronautical navigation.*

Because aircraft move at high speed in three dimensions special problems arise in aeronautical navigation. Radio techniques make a big contribution toward meeting the requirements for the navigation and landing of aircraft during bad visibility. Some of the methods employed are reviewed.

Engineering, **186**, No. 4826, pp. 318–23 (Sept. 5, 1958).

SECTION H

ANTHROPOLOGY AND ARCHAEOLOGY

Thursday, August 28

Local archaeology:

Mr. R. G. Livens.—*Recent researches into the Stone Age in Scotland.*

Since the publication of Mr. A. D. Lacaille's book *The Stone Age in Scotland*, in 1954, much highly significant material has become available for study. An attempt will be made to assess its importance in the study of the earliest settlement in Scotland.

Mr. J. G. Scott.—*From Stone Age to Bronze Age in south-west Scotland.*

The settlement of Neolithic farming communities and the establishment of the Clyde-Carlingford culture in south-west Scotland. The evidence for trade and communications. The introduction of bronze. The replacement of communal burial in chambered cairns by individual burial with food vessel, incense cup or cinerary urn.

Mr. J. Clarke, O.B.E.—*Some aspects of the Iron Age in south Scotland.*

The intrusive population elements and their culture in the immediately pre-Roman period, the nature of the Roman occupation and their impact on native life, the problem of the third and fourth centuries and the transition to the Dark Age will be discussed.

Friday, August 29

Darwin centenary.

Dr. P. A. Jewell.—*Natural history and experiment in archaeology.*

Search for traces of the flora and fauna of the prehistoric environment, like those that Darwin initiated to investigate the denudation of the land, makes an essential contribution to the interpretation of archaeological discoveries.

Adv. of Science, Dec., 1958.

Mr. D. G. MacRae.—*Darwinism and the concept of social evolution.*

An attempt to assess the influence of Darwinism on the analysis of social change by sociology and social anthropology.

Mr. Tom Harrisson.—*A. R. Wallace, apes and ideas in Borneo during one century of evolution.*

A reassessment of Wallace's work and its influence on Darwinism; the animals he studied particularly with reference to evolution, from a modern angle; his problems and the conditions in which he worked in contrast, sometimes unfavourably, with work and working conditions in the same areas today.

Dr. K. P. Oakley, F.B.A.—*Significance of stone tools found in association with* Australopithecus *at Sterkfontein.*

Hominids of the genus *Pithecanthropus* (brains ±1000 c.c.) were certainly capable of tool-making; it has been assumed that the less evolved *Australopithecus* (brains±500 c.c.) were only capable of tool-using. The discovery of pebble-tools at Sterkfontein raises the question whether tool-making antedated brain enlargement.

Cf. 'Tools makyth man', *Antiquity*, **31**, No. 124, pp. 199–209 (Dec. 1957); 'Tools or brains: which came first?' *Archaeol. News Letter*, **6**, No. 6, pp. 148–9 (Feb. 1958).

Monday, September 1

PRESIDENTIAL ADDRESS by Dr. Iorwerth C. Peate on *The study of folk life and its part in the defence of civilisation.*

Primitive beliefs and customs in the modern world:

Mr. C. I. Maclean.—*Traditional Scottish beliefs in the modern age.*

Discussion regarding popular beliefs and practices which still have not lost their meaning in the more sophisticated Scotland of today with instances of belief in fairies, mermaids, supernatural beings, second sight, lucky and unlucky things and actions.

Mr. T. M. Owen.—*Folk customs in Wales.*

An examination of some Welsh folk customs with particular reference to their social setting and its influence upon them.

Cf. Trefor M. Owen, *Welsh Folk Customs*, National Museum of Wales (Welsh Folk Museum), Cardiff.

Tuesday, September 2

Rural settlement. (*See entry under Section E.*)

Simple and advanced techniques in modern society:

Dr. I. Whitaker.—*Traditional techniques in modern Scottish farming.*

Many techniques, generally considered to indicate a primitive economy but which in fact are well adapted to the physical and cultural environment, are

still followed in Scottish farming. This is especially the case in the crofting economy. Some of these, e.g. the shieling, the caschrom, etc., are here discussed.

To appear in *Scottish Studies*, III, pt. 1 (April 1959).

Mr. G. B. Thompson.—*Rural industry in modern Ulster society.*

A recent survey of rural industries in two counties of Ulster was aimed at justifying, if possible, a local Rural Industries Bureau. But the resultant information shows that changes have already taken place which reflect the interaction of traditional industry and modern Ulster society.

Mr. F. G. Payne.—*Retention of simple agricultural techniques.*

Observations on a few simple methods and implements used in cultivation, harvest and farm transport, with consideration of factors affecting their retention or supersession.

Mr. J. G. Jenkins.—*Sledges and wheeled vehicles.*

The evolution of agricultural transport with special reference to the persistence of some primitive vehicles in the British Isles, and to the distribution of carts and waggons throughout Europe and Asia.

Wednesday, September 3

The Niah great cave, Sarawak:

This magnificent cave, with a floor space of 26 acres, has produced for the first time in South-East Asia, a coherent sequence of cultures and human remains, free from geological or climatic modifications to any significant extent. The deposits have yielded a great wealth of artefacts, human skeletons and food remains, and have given a carbon 14 reading of *c.* 40,000 B.C. with habitation continuing well below this. These remains can be interpreted as an unbroken sequence of human evolution in Borneo from the Upper Palaeolithic through the Mesolithic and Neolithic into the metal age.

Lord Medway.—*Life by the million.*

The cave as a food reservoir.

Animal life and prehistory.

Cine film showing the archaeological technique of cave excavation, the animal life and the cave in prehistory.

Mr. Tom Harrisson.—*Borneo man at Niah great cave.*

How man, from Palaeolithic times to the present day, adapted himself to life in a cave.

SECTION I

PHYSIOLOGY AND BIOCHEMISTRY

Thursday, August 28

Life at low temperatures. (*See entry under Section D.*)

The nature of viruses:

Dr. M. G. P. Stoker.—*Intimate lives revealed: the general characteristics of viruses.*

The structure of virus particles as shown by electron microscopy and chemical analysis, with special reference to viruses causing disease in man and animals. The interaction of virus and cell, cell damage and current views on virus multiplication.

Dr. Sidney Brenner.—*The construction of a bacterial virus.*

Structure of bacterial viruses as shown by electron microscopy and other methods. The life-cycle of bacteriophages, with emphasis on vegetative reproduction and the assembly of the infective particle.

Dr. Alick Isaacs.—*How to interfere with a virus.*

The virus interference phenomenon, in which one virus interferes with the growth of a second, has been taken advantage of to prepare an antibiotic, called interferon, which interferes with the multiplication of a number of viruses. The theoretical and practical implications will be discussed.

Cf. A. Isaacs & J. Lindenmann, 'Virus interference. I. The interferon', *Proc. Roy. Soc.* B **147**, 258 (1957); A. Isaacs, J. Lindenmann & R. C. Valentine,

'Virus interference. II. Some properties of interferon', *Proc. roy. Soc.* B **147**, 268; (1957); J. Lindenmann & A. Isaacs, 'Versuche über Virus-Interferenz', *Schweiz. Z. Path. Bakt.* **20**, 640 (1957); J. Lindenmann, D. C. Burke & A. Isaacs, 'Studies on the production, mode of action and properties of interferon', *Brit. J. exp. Path.* **38**, 551 (1957); D. C. Burke & A. Isaacs, 'Further studies on interferon', **39**, 78 (1958); A. Isaacs & D. C. Burke, 'Interferon: a possible check to virus infections', *New Scientist* (June 5, 1958).

Colour vision. (*See entry under Section J.*)

Friday, August 29

Progress in microscopy. (*See entry under Section D.*)

Sound and speech:

Prof. D. Whitteridge, F.R.S.—*Respiratory muscles and speech.*

Air in the chest is passively expelled by the elasticity of the lungs and chest wall. These forces produce the *relaxation pressure*. If we wish to use a lower pressure to speak softly we excite the inspiratory muscles. To speak loudly we have to increase the pressure with expiratory muscles.

Cf. M. H. Draper, P. Ladefoged & D. Whitteridge, 'Expiratory muscles involved in speech', *J. Physiol.* **138**, 17–18 (1957); M. H. Draper, P. Ladefoged & D. Whitteridge, *J. Speech & Hearing Res.* (1958–9); P. Ladefoged, with M. H. Draper & D. Whitteridge, *Misc. Phonetica* (Dec. 1958).

Prof. F. Buchthal.—*Electromyography of intrinsic laryngeal muscles in man*

Mr. James Calnan.—*The function of the palate and pharynx in speech.*

An examination of the mechanism of closure of the nasopharynx: its influence in normal and abnormal speech and its bearing on treatment of patients.

Cf. J. S. Calnan, *Brit. J. plast. Surg.* **5**, 286 (1952); *Brit. J. plast. Surg.* **6**, 264 (1953); *Plast. reconstr. Surg.* **13**, 275 (1954); *Speech*, **19**, 14 (1955); *Brit. J. plast. Surg.* **8**, 265 (1956); *Brit. J. plast Surg.* **10**, 89 (1957); *Speech*, **21**, 59 (1957); *Brit. med. J.* **1**, 737 (1958).

Mr. Peter Ladefoged.—*Speech as a physiological process.*

Differences between speech sounds may be described in terms of physiological activities, such as the action of respiratory muscles, the state of the glottis, and the movements of the lips, tongue and velum. The neurological processes involved in the control of these activities are not yet fully understood.

Monday, September 1

PRESIDENTIAL ADDRESS by Dr. E. N. Willmer on *Some aspects of cellular differentiation.*

The processes by which the different organs and tissues of the human body differentiate are as much a problem in evolution as the origin of man. The effects of simple environmental factors on the forms of cells in primitive organisms will be considered in relation to basic problems in embryology.

Dr. Willmer will show a film entitled *Metaplasia in an Amoeba* ('How an amoeba learns to swim') at the conclusion of his Address.

Salt and water balance in animal life.

Dr. Honor B. Fell, F.R.S.—*The role of vitamin A in differentiation.*

Vitamin A plays an important part in controlling the differentiation of certain tissues; either deficiency or excess of this vitamin may produce remarkable transformations in both the structure and functions of cells.

Cf. H. B. Fell & E. Mellanby, *J. Physiol.* **119**, 470 (1953); H. B. Fell, *Proc. roy. Soc.* B **146**, 242 (1957); H. B. Fell, E. Mellanby & S. R. Pelc, *Brit. med. J.* **2**, 611 (1954).

Dr. T. Vickers.—*The relation of cell structure to secretory activity.*

A consideration of the ways in which the pattern of cell structure is modified during differentiation and in various functional states in cells specialised for the secretion of ions or mucus.

Salt and water balance in animal life. (*See entry under Section D.*)

Tuesday, September 2

Physiological problems in aviation:

Group Capt. W. K. Stewart, C.B.E., A.F.C.—*The continuum of aviation physiology.*

The study of the normal reactions of the human body to changes in the environment occurring in flight shows many features which will probably be common between conditions of today and conditions in the future. In many cases the differences between flight in a manned orbital vehicle and flight in a supersonic aircraft will be one of degree.

Dr. D. McK. Kerslake.—*Some aspects of the control of body temperature in flight*

Kinetic heating introduces the possibility of severe thermal stresses in flight. The experiments described form part of an investigation into the physiological control of sweat production.

Sqn. Ldr. J. Ernsting, O.B.E.—*Effects of reduced atmospheric pressure on man and their prevention.*

Direct exposure of man to low atmospheric pressures can cause anoxia, decompression sickness and boiling of tissue fluids. Protection against these effects may be afforded by means of a sealed cabin or by a pressure suit. The physiological problems occurring in association with these two methods of protection are discussed.

Sqn. Ldr. T. C. D. Whiteside.—*Future problems in aviation physiology.*

A pilot normally experiences for a short time the effects of turning motions and of the absence of gravitational pull, but in future the action of these stimuli may be considerably prolonged. Consequently physiological responses to them will be more marked. Some visual problems will also be described.

Wednesday, September 3

Host-parasite relationships. (*See entry under Section M.*)

Physiology as an education and as a career. (*Joint session with Section L (Education) and the Physiological Society*):

Nature, **182**, No. 4642, pp 1065–7; to appear in *Adv. of Science*, 1959.

Prof. A. V. Hill, C.H., O.B.E., F.R.S.—*Introduction* (read by Prof. R. W. Gerard).

Dr. J. A. B. Gray.—*Physiology in universities.*

Emphasis will be placed on the teaching of physiology as a subject ancillary to other science degrees and of research contacts with other science departments.

Mr. H. P. Ramage.—*Physiology in schools.*

This topic will be considered in relation to the *Science and Education* policy statement recently published by the Committee of the Science Masters' Association. Emphasis will be placed on how physiology, as part of a school course of biological science, might help to heal a gaping wound in the living body of knowledge.

Dr. W. Cobb.—*Physiology in medical research.*

The history of electroencephalography and its relationships to neurology on the one hand and pure cerebral electrophysiology on the other illustrates the opportunities for advancement of knowledge which may arise from any discovery which has clinical applications, and the difficulties which may be encountered in realising them.

Dr. D. P. Cuthbertson, C.B.E.—*Careers for the physiologist in agricultural research.*

Reference will be made to the physiology of the infant animal, to systems of rearing, to reproduction and to the endocrinology of animals of agricultural importance, and particularly to recent research on the peculiar physiology of the ruminant. Reference will also be made to environmental physiology and to insect physiology. These will reveal the rich fields of discovery opening out, many of which can be best developed in collaboration with biochemist and microbiologist.

Dr. J. Yule Bogue.—*Physiology in industry.*

1. Applied human physiology, with special reference to the limitations of human endurance, environmental factors and work study. 2. Comparative physiology, particularly in the field of chemotherapy where there is a blending of physiology into pharmacology, experimental pathology and biochemistry.

Prof. D. H. Smyth.—*The training of physiologists.*

SECTION J

PSYCHOLOGY

Thursday, August 28

Dr. R. H. Thouless.—*Effect of prejudice on reasoning.*

A series of arguments was devised and subjects were asked to indicate whether they agreed with the conclusion and whether they considered the reasoning sound or unsound. An index was calculated for each subject to indicate how far an opinion as to the correctness of the conclusion biased judgment on the soundness of the reasoning.

To appear in *Brit. J. Psychol.*

Cf. R. H. Thouless, *Straight and Crooked Thinking* (E.U.P. and Pan).

Mr. J. E. Orme.—*Personality correlates of the E.E.G.*

A range of variation exists between the E.E.G.s of individual persons. Similarly, people vary with respect to personality types and traits. This paper gives an account of attempts to correlate E.E.G. phenomena with personality make-up, paying special attention to work at the Crichton Royal.

Cf. W. McAdam & J. E. Orme, 'Personality traits and the normal E.E.G.', *J. ment. Sci.* **100**, 913 (1954); W. McAdam, A. C. Tait & J. E. Orme, 'Initial psychiatric illness in involutional women—III. Electroencephalographic findings', *J. ment. Sci.* **103**, 824 (1957); W. McAdam & J. E. Orme, 'Psychological test performance and the E.E.G. in normal old people' (to be published).

Dr. P. H. Venables.—*The slowness of schizophrenics in dealing with complex tasks.*

It has been stated that as the complexity of a task increases so the speed with which schizophrenics deal with it is disproportionately reduced. The conditions under which this impairment is found are examined by making use of concepts derived from information theory.

Canad. J. Psychol. (Oct. 1958).

PRESIDENTIAL ADDRESS by Professor R. W. Pickford on *A review of some problems of colour vision and colour blindness.*

Research papers on colour vision.

Dr. W. A. H. Rushton, F.R.S.—*The chemical basis of human colour vision.*

The human retina distinguishes red from green because the cones contain two visual pigments, one more sensitive to red and one to green. By measuring the light reflected from the depths of the eye these pigments have been analysed in normal and colour-blind persons. The red-blind lacks red pigment.

Research (Oct. 1958).

Commander Dean Farnsworth.—*A trial framework for the study of colour discrimination.*

The study of colour differences has been retarded because of confusions arising from lack of standard conditions of experimentation and of common, even if arbitary, subjective reference standards. To facilitate intercomparisons of studies, a new uniform chromaticity scale diagram, together with certain viewing conditions, will be proposed for general adoption in studies of subjective colour measurement.

Dr. D. H. Fender.—*The effect of eye movements on colour vision.*

If a retinal image is formed in such a way that it remains stationary on the receptors irrespective of normal eye movements, then certain changes occur in the perception of colour. Some experimental results will be described.

Mr. R. Lakowski.—*Age and colour vision.*

A random sample of people placed into eight age groups (e.g. 5–10 . . . 50–60 years of age) were tested on the Pickford Anomaloscope and various pseudo-isochromatic plates in order to find the influence of age upon the discrimination ability in the following equations: red-green, yellow-blue and violet-blue/green.

To appear in *J. gen. Psychol.*; *Adv. of Science*, Dec., 1958.

Friday, August 29

The usefulness of psychology to the teacher.

Mr. R. Edwards.—*Research in educational psychology: methods and findings.*

Educational psychology is a subject in its own right, with methods similar to any other applied science. It is not concerned primarily with the aims of

education but with the achievement of those aims. Utilisation by teachers of its findings would contribute a great deal to educational practice.

Engineering (Sept. 5, 1958); condensed version to appear in *Research*.

Dr. S. Wiseman.—*Educational psychology in retrospect.*

The trends in research in educational psychology over the last twenty-five years are examined, and certain strengths and weaknesses discerned. The reasons for lack of balance over the whole field are considered, with particular reference to the needs of education and the school system.

To appear in *Scot. J. Pol. Econ.*, Feb., 1959.

Mr. E. Britton.—*Educational psychology: the consumer's approach.*

The ordinary teacher's attitude to the educational psychologist. How much does he owe? How far does he acknowledge the debt? And how far does he remain sceptical? In what ways does the teacher believe that the psychologist could help him in the classroom?

Mr. D. C. Duncan.—*Confidence as an integrating concept in psychology and economics.*

The working of economic systems depends on relationships of confidence, but economists have left confidence for psychologists to study as a psychological phenomenon. Psychologists, however, have underrated its importance, preferring more objective measures of performance. Studies of confidence and its determinants could provide a significant link between economics and psychology.

Mr. W. H. N. Hotopf.—*Comprehension and newspaper correspondence.*

This communication is concerned with the understanding of written material. Following on a study of the correspondence columns of two papers, a popular issue, that of attitudes to punishment, was experimentally investigated, to find out the extent of misunderstanding taking place and the conceptions of its author given written material conjures up.

Prof. J. Cohen.—*The metaphorical consciousness.*

What is the role of the human imagination? Intelligence takes things literally, imagination takes them 'symbolically', and man is perhaps more an imaginative than an intelligent animal. The implications for psychological theory and practice are considered of (*a*) the appreciation of metaphor acquired by the growing child and lost in schizophrenia and brain injury, and (*b*) the forms of metaphorical interpretation that characterise mythical and other types of thinking.

To appear in *The New Scientist*. An expanded treatment of one section of the paper will appear in *Proceedings of the International Congress of Psychotherapy* (Barcelona, Sept. 1958).

Mr. A. E. G. Pilliner.—*Standardisation errors of Moray House verbal reasoning tests.*

Increased test sophistication raises the average 'raw scores' of groups of children on whom recent test standardisations are based. Hence tests recently standardised give lower 'quotients' than tests standardised earlier. Corrections are necessary to render comparable 'quotients' from different tests. The 'cross over' design, slightly elaborated, is used to obtain these corrections.

Monday, September 1

Research papers on occupational psychology:

Nature, **182**, No. 4641, pp. 993–5.

Mr. J. G. M'Comisky and Dr. P. P. Daws.—*The selection of shipbuilding and marine engineering apprentices.*

The development of an apprentice selection scheme in a Glasgow shipyard will be described. Particular reference will be made to the effect of adding a short interview to the selection test battery, and to how the scheme was planned so as to enable it to be taken over by the firm's apprentice supervisor.

Mr. R. M. McKenzie.—*The inspector-workman relationship.*

Relations between inspector and production operator are often—understandably—strained. Some factors making for good or bad relations were examined. It turns out, for instance, that inspectors are in fact often less consistent than expected. Some implications of the research for the selection and training of inspectors will be outlined.

Cf. R. M. McKenzie & D. S. Pugh, 'Some human aspects of inspection' *Instn prod. Engrs J.* **36**, 378–87; R. M. McKenzie, 'On the accuracy of inspectors', *Ergonomics*, **1**, No. 3, pp. 258–72.

Mr. H. Dale.—*Fault-finding.*

A study in which the way engineers search for faults in electronic equipment is related to the way ordinary people perform analogous searching tasks in the laboratory.

Cf. H. Dale, 'Fault finding in electric equipment', *Ergonomics*, **1**, 356–85; 'The training of maintenance engineers' (two articles), *Brit. Comm. & Electronics* (in press) (Jan. & Feb. 1959).

Dr. Nairn Cowan.—*Retirement: a critical phase in the life of man.*

Retirement results in a radical alteration in the way of life. Many men are unable to make this adjustment satisfactorily, and through trial and error reach an unstable equilibrium with their environment. A feeling of uselessness is prevalent. Education in the attainment of a 'full' life is necessary and ideally this teaching should begin at school.

Cf. N. R. Cowan & W. Ferguson Anderson, 'Work and retirement: influences on the health of older men', *Lancet*, **ii**, 1344 (1956).

Research papers on social psychology:

Dr. H. E. Page.—*Social-psychological research in the United States.*

The communication will indicate the extent of support for social-psychological research and indicate the nature of such research by citing examples.

Dr. Josephine Klein.—*An analysis of the literature on the family in post-war Britain* (read by Mr. D. E. Broadbent).

Community studies provide almost our only public knowledge on the family. The facts gleaned from these publications are arranged in a tentative theoretical framework.

Dr. G. Jahoda.—*Personal problems and social change in Ghana.*

Mr. P. Willmott.—*Kinship, social class and old age in a London suburb.*

A sample of 200 people of pensionable age, living in a London suburb (Woodford), was interviewed. The paper reports the finding of this enquiry in which the main interest was to see how the kinship relationships of old people with children and other relatives differed in different social classes.

Tuesday, September 2

Delinquency:

To appear in *Adv. of Science*, 1959.

Professor T. Ferguson, C.B.E.—*The young delinquent in his social setting.*

In the course of a study of 1,349 lads who left Glasgow schools at the earliest permitted age, information was collected about social environment and performance after leaving school. The delinquency records of the lads were studied in the light of these factors and this paper summarises the results.

Cf. Capt. Miller, *Report of Glasgow Meeting, B.A.* (1940); J. B. Russell, 'Sociological aspects of sanitation', reprinted, *Roy. San. Ass. Scot.* (1933); Jas. Devon, 'The treatment of the criminal and offender', *Proc. R. phil. Soc. Glasg.* **XXXV** (1903–4); T. Ferguson, *The Young Delinquent in His Social Setting* (O.U.P. 1952); T. Ferguson & J. Cunnison, *In Their Early Twenties* (O.U.P. 1956).

Dr. D. H. Stott.—*Boys on probation: maladjusted or normal?*

A survey of the 500 Glasgow boys placed on probation for the first time during 1957, in order to discover to what extent their delinquency could be regarded as a normal phase of growing up in certain parts of Glasgow, or whether it constituted one among other symptoms of maladjustment.

Mr. L. T. Wilkins.—*Patterns of post-war juvenile and young adult crime.*

Statistical procedures reveal that certain generations are more crime-prone than others (when all disturbing factors are held constant). Some 'crime waves' are explained by this fact while others are not.

Dr. R. G. Andry.—*Paternal and maternal roles and delinquency.*

In recent years much has been published which tends to suggest that faulty mother-child relationships can often be one of the primary causes of delinquency. It is here intended to demonstrate quantitatively that the important role which is played by fathers in this respect has been considerably overlooked by many of those who overstress the importance of 'maternal-deprivation'.

Mr. J. C. Raven.—*Verbal disfunction in mental illness: a comparative study.*

The unusual ways in which patients explain and use words throw light on the different forms of thought disorder noticed in structural and functional mental illnesses. The incidence of unusual qualities can be an aid to differential diagnosis, and sometimes prognosis.

Language & Speech, **1**, part 3 (July–Sept. 1958).

Dr. A. J. Weir.—*A developmental study of value judgments in old age.*

Werner's developmental psychology provides the basis for a method of investigating a subject's evaluations and factual judgments, and deriving information about his relative developmental level. This technique has been applied to a group of elderly Rutherglen people. Results will be considered in relation to the theoretical predictions, and also to age and intelligence level.

Mr. H. R. Schaffer and Miss W. M. Callender.—*The role of the social environment in early personality development.*

An analysis of the growth of the child's relationship to the mother in infancy based on observations of the effects of maternal deprivation. Two developmental phases have been isolated in respect of these effects, and the discussion will concern the respective social needs of infants in these phases.

Mr. H. C. Baker.—*The development and use of technical ideas in a small-firm industry.*

The purpose of the paper is to show the type of evidence from which ideas about industrial processes have been developed by managers and workers in a small-firm industry and how these ideas contribute to or obstruct technical development.

SECTION K

BOTANY

Thursday, August 28

PRESIDENTIAL ADDRESS by Professor R. S. Adamson on *The Cape as an ancient African flora.*

Professor Dr. W. Robyns.—*Some problems in the tropical African mountain flora.*

To appear in *Adv. of Science*, 1959.

Friday, August 29

Morphological and cytological studies, with particular reference to the Pteridophyta:

Dr. S. Williams.—*The persisting problems of morphology.*

A brief survey of some of the problems of phyletic and causal morphology which still remain largely unsolved and of the contribution of modern work to their solution.

Professor I. Manton.—*Cytology of the Pteridophyta.*

A summary of the main lines of cytological work which have been applied to the Pteridophyta.

Professor C. W. Wardlaw.—*Reflections on the unity of the embryonic tissue in ferns.*

A review of the ontogeny of organs of the sporophyte of ferns based on experimental morphogenetic studies, showing that such studies are closely related to the great classical investigations of the Phyletic Period.

Discussion on the structure and evolution of early seeds and ovules:

Professor J. Walton.—*Introduction.*

Mr. A. G. Long.—*Studies in the Lower Carboniferous flora of Berwickshire.*

(1) New information on *Calmmatotheca kidstoni* Calder, showing two distinct types interpreted as simple cupulate megasporangia, and on *Samaropsis scotica* Calder, showing it to have Pteridospermous affinities.

(2) New Pteridospermous seeds and axes, together with a simple type of seed cupule.

(3) *Protoclepsydropsis* (*zygopteris*) *kidstomi* Bertrand, bearing petioles.

Mr. D. L. Smith.—*Lower Carboniferous fructifications from the Kilpatrick Hills.*

Mr. P. D. W. Barnard.—*Notes on petrified Pteridosperm seeds illustrated by some from East Lothian.*

A description of two Scottish, Lower Carboniferous seeds and the organ bearing one of them. A discussion of the variation in Pteridosperm seed-bearing organs, the stratigraphic relationships of these plants remains and their possible evolutionary significance.

Nitrogen metabolism:

To appear in *Adv. of Science*, 1959.

Dr. G. Bond.—*The incidence and importance of biological fixation of nitrogen.*

Present knowledge regarding the occurrence of nitrogen fixation in plant groups will be reviewed. It will be shown that in addition to plants studied by those interested in agricultural aspects, fixation is also effected by some plants whose ecological importance in past and present eras will be considered.

Cf. G. Bond, *Ann. Bot.* N.S. **15**, 447–59 (1951); T. P. Ferguson & G. Bond, *Ann. Bot.* N.S. **17**, 175–88 (1953); G. Bond, W. W. Fletcher & T. P. Ferguson, *Plant & Soil*, **5**, 309–23 (1954); G. Bond, *J. exp. Bot.* **6**, 303–11 (1955); G. Bond & G. D. Scott, *Ann. Bot.* N.S. **19**, 67–77 (1955); G. Bond, *New Phytol.* **55**, 147–53 (1956); G. Bond, *Ann. Bot.* N.S. **21**, 373–80 (1957); G. Bond, *Ann. Bot.* N.S. **21**, 513–21 (1957); I. C. Gardner & G. Bond, *Canad. J. Bot.* **35**, 305–14 (1957).

Dr. G. Leaf.—*Biochemical aspects of the fixation of atmospheric nitrogen.*

The significance of nitrogen fixation in plant nutrition will be discussed and an account be given of our knowledge of the mechanism by which gaseous nitrogen is converted into nitrogenous substances in the plant. Evidence that ammonia is the immediate product of fixation will be discussed and consideration be given to how it may be formed.

Dr. L. Fowden.—*The incorporation of inorganic nitrogen compounds into amino-acids and proteins of plants.*

A general account of the processes leading to the incorporation of ammonia nitrogen and nitrate nitrogen into the amino-acids and proteins of plants, will include a discussion of the central importance of glutamic acid, glutamine, and asparagene in these mechanisms. The possible role of transaminase enzymes will be considered and other processes leading to ammonia incorporation into amino-acids will be mentioned. Developments in the field of protein synthesis will be summarised.

Semi-popular lecture:

Dr. S. Williams.—*On the vegetation of Scotland.*

Monday, September 1

Integration of forestry and agriculture in land use. (*See entry under K.**)

The nature and genetical control of resistance in living organisms.

Nature, **182**, No. 4640, pp. 921.

Dr. R. P. Day.—*The genetics of host and pathogen among diseases of higher plants.*

A discussion of the gene-for-gene relationship between host and pathogen with special reference to the mode of origin of new virulent forms of pathogen.

Miss C. Elizabeth Jackson.— *The genetic basis of resistance mechanisms in mosquitoes.*

An account of resistance to chlorinated hydrocarbon insectisides in malaria-carrying anopheline mosquitoes. The types of resistance and the inheritance mechanisms involved are considered.

Dr. M. Barber.—*The genetics of resistance in bacteria.*

An account of the mechanisms by which bacteria develop resistance to anti-bacterial agents and a survey of the spread of drug-resistant strains in a community.

Dr. A. Kleczkowski.—*Resistance to virus diseases.*

A discussion of various forms of host-virus relationships amongst viruses of bacteria, plants and animals.

The Scottish flora:

Professor J. R. Matthews, C.B.E.—*The Scottish flora—flowering plants.*

Approximately 1,500 species of flowering plants constitute the angiospermous flora of Britain; of these, about 1,060 (or 70 per cent) occur in Scotland; Perth and Angus being floristically rich counties. Although the total flora is small it is remarkably diverse, exhibiting varying affinities with the flora of continental Europe.

Mr. R. Mackechnie.—*Some Scottish plants.*

The talk will deal mainly with plants not known to occur south of the border. Some are endemic, others of very restricted distribution, and a few are of doubtful status.

Dr. Elsie Conway.—*Marine algae in Scotland.*

Appreciation of the marine algal flora of Scotland, particularly the intertidal flora, has increased considerably since 1928, not only by a number of descriptive ecological accounts, but also by attempts to examine the effects of physical factors (wave action; slope; high humidity). Accumulating evidence suggests that many northern shores have affinities with coasts of the North Atlantic islands and mainland rather than with the southern parts of the mainland of Great Britain.

Dr. C. E. Foister.—*The mycological flora of Scotland.*

The field is briefly surveyed from the time of Greville, to the last of the British Mycological Society's revised lists (1954). The work and influence of natural history societies and the Scottish Cryptogamic Society, and of Buchanan-White, Keith, Stevenson, Boyd, Traill and Wilson is discussed. Developments in plant pathology are also mentioned.

Semi-popular lecture:

Dr. P. W. Brian, F.R.S.—*Gibberellic acid.*

Cf. *J. Roy. Soc. Arts*, CVI. 425–41 (1958).

Tuesday, September 2

The work of the Freshwater Biological Association.

Prof. W. H. Pearsall, F.R.S.—*The history of the Freshwater Biological Association.*

Dr. C. H. Mortimer, F.R.S.—*The physics and chemistry of lakes.*

An account of the contributions to the above subject by members of the staff of the Freshwater Biological Association, illustrated by slides and film.

Dr. J. W. G. Lund.—*Investigations on the algae of Windermere.*

The history of algal investigations on Windermere and other lakes in the district. The present state of knowledge of the causes of algal periodicity. Problems for the future and economic aspects.

Mr. E. D. Le Cren.—*Experiments with fish populations in Windermere.*

Investigations into numbers, growth, food, survival and angling of the fish species in Windermere can provide estimates of the total amounts of fish produced in the lake. An experimental reduction in the numbers of perch and pike has helped to show some of the interrelationships between the species.

Wednesday, September 3

Scottish soils.

Dr. R. Glentworth.—*A review of the distribution of soil types of Scotland.*

The distribution of the major soil groups will be shown on a revised soil map of Scotland. Colour slides of representative soil profiles will be shown and their principal properties discussed.

Dr. T. W. Wright.—*Forest soils in Scotland.*

(1) Physical and chemical characteristics of soils which influence choice of species for planting and limit tree growth.

(2) Improvement of these characteristics: (*a*) physically, by drainage and deep ploughing; (*b*) chemically, by application of fertilisers (success of phosphate fertilisers: possible future use of nitrogen and potash fertilisers).

(3) The effect of new forests on soil, with particular reference to deep peat and heather moorland.

To appear in *Emp. For. Rev.* (March, 1959).

Mr. W. A. Mitchell.—*Mineralogical aspects of soil types in Scotland.*

The importance of parent material in pedogenesis will be discussed with reference to age of soils in general and to Scottish soils. Weathering processes will be related to particle size distribution in primary and secondary soil minerals. The pedological significance of the mineralogy of the sand, silt, and clay fractions will be illustrated with reference to particular soils in Scotland.

Cf. W. A. Mitchell, 'A review of the mineralogy of Scottish soil clays' *J. Soil Sci.* **6**, 94–8 (1955); B. D. & W. A. Mitchell, 'The clay mineralogy of Ayrshire soils and their parent rocks', *Clay Min. Bull.* **3**, 91–7.

Dr. R. L. Mitchell.—*Trace element problems in Scottish soils.*

Scottish soils are of such varied geological origin that trace element problems of considerable diversity occur. In plants or animals, deficiencies of such elements as cobalt, copper, manganese and boron, and excesses of molybdenum nickel and other metals have been encountered. Investigations into the factors controlling the uptake of trace elements by plants from different soils are in progress at the Macaulay Institute for Soil Research.

Cf. R. L. Mitchell, 'Trace Elements': chap. 9 of *Chemistry of the Soil* (American Chemical Society Monograph No. 126), ed. F. E. Bear, pp. 253–85 (New York, Reinhold, 1955); L. R. Wager & R. L. Mitchell, *Geochim. et cosmoch. Acta*, **1**, 129–208 (1951); R. L. Mitchell, *Research*, **10**, 357–62 (1957); J. Stewart, R. L. Mitchell, A. B. Stewart & H. M. Young, *Emp. J. exp. Agric.* **14**, 145–52 (1946); R. L. Mitchell, *J. Brit. Grassl. Soc.* **9**, 301–11 (1954); R. L. Mitchell, J. W. S. Reith & I. M. Johnston, *J. Sci. Fd Agric.* **8**, Suppl. S51–9 (1957).

SUB-SECTION K*

FORESTRY

Thursday, August 28

PRESIDENTIAL ADDRESS to Section K by Prof. R. S. Adamson on *The Cape as an ancient African flora.*

CHAIRMAN'S ADDRESS by Prof. H. M. Steven on *The native pinewoods of Scotland and their significance for current forestry practice* (read by Mr. James Macdonald, C.B.E.).

Friday, August 29

Assessment and improvement of the quality of forest tree seeds:

Mr. J. D. Matthews.—*The genetic quality of forest tree seed.*

A general discussion of the assessment and improvement of the inherent quality of tree seed. Emphasis will be placed on the importance of seed origin, the classification and registration of seed sources, progeny testing and the production of seed of superior varieties (cultivars) in seed stands and seed orchards.

Mr. G. D. Holmes.—*Assessment and improvement of the sowing value of seeds.*

Reviews methods of quality assessment and their interpretation for field sowing.

Extended version to appear in *Forestry Commission Forest Record* or *Bulletin.*

Mr. J. R. Thom.—*The value of improved tree seed and quality control in forest practice.*

The importance of improving the quality of forest tree seed, collected in Scotland, by means of a system of classification of tree stands. The setting up of the Scottish Forest Tree Seed Association to supervise this work generally and thus improve the quality of trees in the forests of the future.

Monday, September 1

Integration of agriculture and forestry in land use.

Sir James Denby Roberts.—*The landowner's view of the integration of agriculture and forestry.*

Some practical experiences from Strathallan estate.

Mr. M. A. M. Dickie, O.B.E.—*Rural development surveys in Scotland.*

A review of the surveys being undertaken to secure the integration of forestry and agriculture, with an indication of the objectives, the methods employed, the difficulties encountered and the results achieved.

Mr. J. A. B. Macdonald.—*Integration of forestry and the hill sheep farm.*

Recent farming/forestry collaboration results in land re-allocations providing dual advantages. Re-allocations range in scope from small farms where unwanted land is being forested partly to improve shelter, to trackless sheep farms where a new Forestry Commission road is the key to developing both roadside forestry blocks and agriculture.

Mr. R. M. Hamilton.—*The factor's view of the integration of agriculture and forestry.*

The problem of integration as seen and practised by the large estate advised properly, and how this fits into the national plan.

J. R. Instn chart. Surv. Scott. Suppl. (Oct. 1958).

Tuesday, September 2

The supply and utilisation of fast-grown coniferous timber:

Mr. Andrew Watt.—*The management of fast-grown conifers.*

Some aspects of forest management with particular reference to western Scotland.

To appear in *Timb. & Plywood.*

Mr. B. J. Rendle.—*Some anatomical considerations.*

The relation between rate of growth and timber quality depends on the structure of the growth ring, which varies with the species, the age of the tree and conditions of growth.

Timb. & Plywood (Sept. 25, 1958) (summary); slightly amended version in *Quart. J. For.* (Jan. or April 1959).

Cf. B. J. Rendle & E. W. J. Phillips, 'The effect of rate of growth (ring width) on the density of softwoods', *Forestry* (The Journal of the Society of Foresters of Great Britain), **31** (2), 113–20 (1958).

Mr. R. Finlay Wilson.—*Utilisation and the sawmilling industry.*

The utilisation of fast-grown coniferous timber in the sawmilling industry.

Mr. E. G. Richards.—*Market trends.*

Some aspects of the changing pattern of wood utilisation and their possible effects on the marketing of fast-grown coniferous timber.

Timb. Tr. J. (Sept. 6, 1958).

Wednesday, September 3

Scottish soils. (*See entry under Section K.*)

SECTION L

EDUCATION

Thursday, August 28

Education in a technological age—1 (with special reference to university education):

Professor F. A. Vick, C.B.E.—*Education in a technological age: the university aspect.*

A discussion of the problems encountered in the liberal education of scientists and technologists in universities and colleges of advanced technology, and in the teaching of science to non-scientists. The discussion is based partly on experience at Keele, but not confined to this.

Cf. F. A. Vick, 'The problem of overspecialisation', *London Calling* (June 21; 1956); 'Science for the non-scientist'. *Universities Quart.* **11**, 245 (May 1957), 'The educative value of physics courses', *Advanc. Sci.* **12**, 540 (1956).

Dr. Andrew Kent.—*Science classes for arts students.*

Courses for arts students at Glasgow, with special reference to new courses in zoology and chemistry, to the student type which enrols, and to the effect of the courses on them.

Friday, August 29

Miss Mary Rodger.—*Job satisfaction.*

A study conducted amongst seventeen-year-old youths in the city of Edinburgh to assess the proportion of those dissatisfied in their work; to consider job satisfaction in relation to intelligence, occupations level, reason for choice of job, stability in job, evening class attendance, and wages; to study job satisfaction in relation to whether the choice of job was in accordance with vocational guidance or contrary to it.

PRESIDENTIAL ADDRESS by Sir Willis Jackson, F.R.S., on *The partnership between industry and education.*

Nature, **182**, No. 4638, pp. 749–50.

The usefulness of psychology to the teacher.

Mr. R. Edwards.—*Research in educational psychology: methods and findings.*

Educational psychology is a subject in its own right, with methods similar to any other applied science. It is not concerned primarily with the aims of education but with the achievement of those aims. Utilisation by teachers of its findings would contribute a great deal to educational practice.

Dr. S. Wiseman.—*Educational psychology in retrospect.*

The trends in research in educational psychology over the last twenty-five years are examined, and certain strengths and weaknesses discerned. The reasons for lack of balance over the whole field are considered, with particular reference to the needs of education and the school system.

Mr. E. Britton.—*Educational psychology: the consumer's approach.*

The ordinary teacher's attitude to the educational psychologist. How much does he owe? How far does he acknowledge the debt? And how far does he remain sceptical? In what ways does the teacher believe that the psychologist could help him in the classroom?

Problems of small firms in providing continued education facilities:

Miss Anne G. Shaw, C.B.E.—*The training of girls.*

Opportunities and problems in the training of girls for engineering and technical posts.

Mr. J. E. C. McCandlish, C.B., C.B.E.—*Training and education in medium and small firms.*

Where facilities and suitable staff are not available, grouping should be the solution, either by interchange of training facilities or, like the Scottish Electrical Training scheme, a formal association of eight 'units' (firms and boards) to pool resources for very comprehensive graduate, and vacation, training.

Monday, September 1

The Student Day:

Professor W. R. Niblett.—*The Hall of Residence.*

The value, function and opportunities of residential halls in the modern university today.

To appear in *Times Ed. Suppt.*

Dr. F. Crawford.—*Antidotes to apathy.*

The reasons for non-participation of a large proportion of university students in the corporate life of the university; the effect of this on the benefits derived from university education, and the steps to be taken which might improve the present situation.

Adv. of Sci., Dec,, 1958.

Tuesday, September 2

The teaching of mathematics. (*See entry under Sub-Section A**.)

Education in a technological age—2 (with special reference to secondary school education):

Sir James J. Robertson, O.B.E.—*The lesser and the greater tasks.*

Mr. G. B. C. Palmer.—*The work of a bilateral (technical and modern) secondary school in a new town.*

An account of the policy, organisation, practice and potentialities of a bilateral school in a new town.

Wednesday, September 3

Education in a technological age—3 (with special reference to the training of teachers in a technological age):

Prof. W. O. Lester Smith, C.B.E.—*Some reflections on the professional education of teachers.*

Developments and trends; modern demands of schools, and their diversity. Problems of our time that specially concern teachers, including that of educating in a scientific age. The importance of in-service courses and visits at home and abroad in a period of change.

Physiology as an education and as a career. (*See entry under Section I.*)

SECTION M

AGRICULTURE

Thursday, August 28

PRESIDENTIAL ADDRESS by Dr. D. P. Cuthbertson, C.B.E., on *Digestion in the ruminant.*

Dr. J. A. F. Rook.—*Grass tetany.*

An account of the occurrence and nature of this disorder of cattle. Investigations showing the invariable association with hypomagnesaemia, the factors known to influence the field occurrence and the changes in metabolism involved, are described. Practical methods for the control of 'grass tetany' are outlined.

Cf. S. Bartlett, B. B. Brown, A. S. Foot, M. J. Heas, C. Line, J. A. F. Rook, S. J. Rowland & G. Zundel, 'Field investigations into hypomagnesaemia in dairy cattle, with particular reference to changes in the concentration of blood constituents during the early grazing period', *J. agric. Sci.* **49** (3), 291 (1957); J. A. F. Rook, C. C. Balch & C. Line, 'Magnesium metabolism in the dairy cow. 1. Metabolism on stall rations', *J. agric. Sci.* (1958); J. A. F. Rook & C. C. Balch, 'Magnesium metabolism in the dairy cow. 2. Metabolism during the spring grazing period', *J. agric. Sci.* (1958).

Professor Charles Evans.—*Bracken poisoning of farm animals.*

The lecture will outline the problem of cattle bracken poisoning, and 'bracken staggers', in the horse. Historical development of the scientific work to elucidate the various effects of including bracken in the diet of animals. Relevant biochemistry of *Pteridium aquilinum* which has a bearing on bracken poisoning of animals; mode of production of the disease; isolation of the toxic factors; and therapy.

Friday, August 29

Nutrition and milk production in cattle, sheep and pigs:

Professor H. D. Kay, C.B.E., F.R.S.—*Nutrition and milk production in cattle.*

Energy and material requirements of the ruminant udder for milk production. Synthesis of the milk constituents. Changes in quality and quantity of the feed and their effects on milk quality and quantity.

Mr. Oscar H. Colburn.—*Breeding productive sheep.*

An assessment of the desirable qualities in British sheep is followed by consideration of suitable breeding methods. The system in operation in a Clun forest flock at Crickley Barrow in Gloucestershire is described and observations made upon the results obtained.

Mr. G. A. Lodge.—*Nutrition and milk production in sows.*

A review of what is known about the effect of the nutrition of lactating sows upon the yield and composition of their milk.

Cf. *Pig Fmg*, 6, No. 9, p. 37, and No. 10, p. 35, and *Fmrs' Wkly* (Sept. 5, 1958).

Monday, September 1

Integration of agriculture and forestry in land use. (*See entry under K*.*)

Horticultural session: the plant and its environment (Chairman—Mr. David Lowe, C.B.E.):

Mr. A. B. Webster.—*The effect of environment on the economics of chrysanthemum growing.*

The effect of varying degrees of competition for soil water and plant foods and for light on the yield and profit produced by late-flowering chrysanthemums were investigated. Practical applications of these results are discussed.

Dr. A. J. Cooper.—*Growth trends of the glasshouse tomato.*

A preliminary report on studies of the development of all the organs of the Potentate variety of tomato (excluding the roots) in relation to the age of the organ and the time of the year.

Professor J. P. Hudson, M.B.E.—*The use of controlled environments in experimental work.*

Brief reference to forms of environmental control used in experimental work with plants, types of work at present being undertaken in controlled environments and significance of results from an agronomical point of view. Future policy regarding development of environmental control equipment.

To appear in *Adv. of Science*, 1959.

Dr. C. G. Guttridge.—*The use of controlled environment chambers to investigate the physiology of the strawberry.*

A report of investigations in controlled environment chambers into the influence of the seasonal climatic cycle on the growth and development of the cultivated strawberry.

Cf. C. G. Guttridge, 'Effects of winter chilling on the subsequent growth and development of the cultivated strawberry plant', *J. hort. Sci.* **33**, 119 (1958).

Tuesday, September 2

The application of science to hill farming:

Adv. of Science, Dec., 1958.

Mr. A. R. Wannop, O.B.E.—*A review of hill farming problems.*

A review of hill farming problems, particularly the improvement of hill grazings, the influence of methods of land use and hill management on the plant communities and on fertility, the nutrition of hill sheep and methods of increasing animal output and the intregation of hill and lowland farming.

Mr. A. L. Wilson.—*Health in hill flocks.*

The importance of hill sheep will be mentioned. A tribute will be paid to the Animal Diseases Research Association. The difficulties of disease control in hill sheep will be explained. Reference will be made to the diseases that may occur when hill pastures are improved. Control of these diseases will be described.

Mr. J. B. McCreath.—*The economics of hill farming.*

A brief résumé of the scope of hill farming in Scotland. The average financial return from such farming and some economic factors affecting this return, with special reference to West of Scotland conditions.

Dr. R. F. Hunter.—*Hill land improvement.*

Improvement is measured in terms of utilised improvement, and utilisation presents different problems according to the stocking intensity, type of vegetation and system of management of any particular hill pasture.

Wednesday, September 3

Host-parasite relationships.

Dr. J. J. Bullen.—*Immunity to bacterial infections.*

Many pathogenic bacteria are capable of invading and growing in living tissue; others produce toxic substances which can penetrate living membrane. The host has numerous defences. The struggle for survival is determined by the efficiency of these invading or defending mechanisms.

Dr. W. Mulligan.—*Vaccines against parasitic worms.*

An experimental study is described on immunity to lungworm disease in cattle involving a series of experiments aimed at producing an immunity artificially. The best immunity results from the administration of larvae attenuated by X- or by gamma rays and a successful vaccine based on this method has been developed.

Dr. J. A. Campbell.—*Host parasite relationships in the Diptera.*

In certain insect groups, e.g. the lice, the universal and long-established parasitic habit obscures their phylogenetic relationships. Parasitism is of much more recent appearance in the Diptera, and they present an interesting and varied range of parasite-host relationships.

Dr. J. R. Norris.—*Bacteria and insects.*

The group of aerobic sporeforming bacteria typified by *Bacillus thuringiensis* and their relationship with insect hosts such as *Ephestia kuhniella* (the meal moth) considered in the light of recent developments in our knowledge of the mechanisms underlying their pathogenicity.

SECTION X

ASSEMBLY OF CORRESPONDING SOCIETIES

Thursday, August 28

Dr. W. E. Swinton.—*Darwin in Scotland.*

The importance of the Scottish part of Darwin's life, when for two sessions he was a medical student at Edinburgh University. Here he was stimulated to an interest in natural history by several friendships and here he read his first scientific paper.

Adv. of Science, Dec., 1958.

Mr. B. W. Ribbons (*A*) and Dr. S. M. K. Henderson (*B*).—*Field studies in the Loch Katrine area.*

A. The Scottish Field Studies Association. Flora of The Trossachs.

B. Brief account of the Dalradian rocks and an interpretation of the geological structures around Loch Ard and Loch Katrine.

PRESIDENTIAL ADDRESS by the Rt. Hon. Lord Boyd Orr, D.S.O., M.C., F.R.S., on *The cultural value of local societies.*

Friday, August 29

The presentation of science:

The Rt. Hon. Lord Boyd Orr, D.S.O., M.C., F.R.S.—*Introduction.*

1. *To junior audiences.*—Mr. Marcus Morris.

   Our task in presenting science to junior audiences is to offer them, at their own level of understanding, content which will feed their natural curiosity, stir their imaginations, and develop in them a right attitude to science and scientists. The practical aspects of this task will be discussed.

2. *To adult audiences.*—Mr. P. Ritchie Calder, C.B.E.
3. *By scientist to scientists in differing subjects.*—Mr. L. J. F. Brimble.
4. *Through the medium of television.*—Miss F. R. Elwell.

   Extracts from telerecordings of schools' television programmes will be shown to illustrate some of the ways in which television can contribute towards education in science.

Conference of delegates of affiliated societies to be opened by the Rt. Hon. Lord Boyd Orr, D.S.O., M.C., F.R.S., President of the Section.

Monday, September 1

Mr. J. G. Scott.—*Local societies and archaeological research in Scotland.*

A summary of research into the archaeology of Scotland carried out by local archaeological and antiquarian societies during the past century; the results achieved, and the scope and possibilities for similar research in the future.

Dr. C. H. Mortimer, F.R.S.—*Marine biology at Millport.*

A general account of the various lines of research in progress and of the laboratory, research vessels and equipment.

Tuesday, September 2

Science by the upper form:

Mr. Albert M. J. Hutchings and Mr. Andrew J. Nicholl.—*Plant ecology of heather, moor and bog.*

Mr. Alan Nicol.—*The production of special steels.*

Mr. J. C. Natzio.—*The work of 'Discovery II'.*

A short account of the work done and methods used on a recent biological cruise of the R.R.S. *Discovery II* in the North Atlantic.

Mr. D. W. McCredie.—*The breeding habits of the hen harrier in south-western Perthshire.*

Hen harriers have been shown to breed now for several years on the south-western Perthshire moors. The communication includes not only a study of the breeding habits of these birds but also a study of the young hen harriers at the nest.

ADVANCEMENT OF SCIENCE, XIV, No. 57, JUNE 1958

ANIMAL HEALTH IN RELATION TO BRITAIN'S FOOD SUPPLIES

BY J. N. RITCHIE, C.B.

CORRIGENDA

Pages 431–440:

1. It is regretted that in preparing this article for publication an error in pagination occurred. The material which appears on page 433 (second paragraph—beginning 'There are regular patterns of major movements') to page 435 (first paragraph—ending 'and virus hepatitis of ducks, of which the origin is obscure, but for which a valuable vaccine has since been developed') should be read in its entirety **after** the material which runs from page 435 (paragraph beginning 'Vaccination has obviously succeeded in protecting stock against infection') to page 437 (second paragraph—ending 'are now well distributed over the country').

2. The heading of Table II which appears on page 434 should be amended to read 'Number of outbreaks of notifiable diseases'—except in so far as the Tuberculosis Order is concerned: it should say 'cattle slaughtered'.

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